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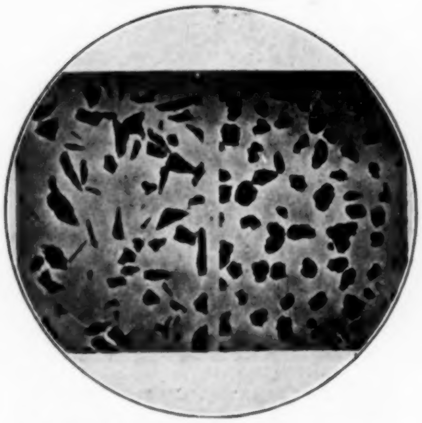

Fig. 1 Crystalline and Amorphous Natural Graphite

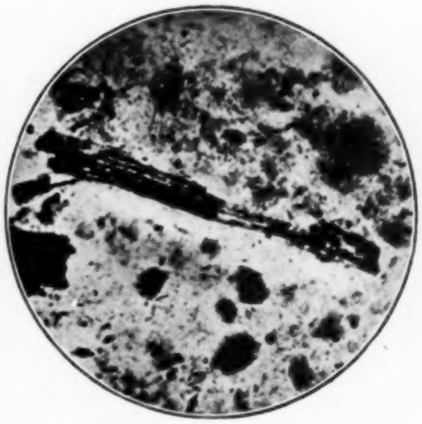

Fig. 2 Cross-Section of a Flake of Micaceous Graphite (200 Diameters)

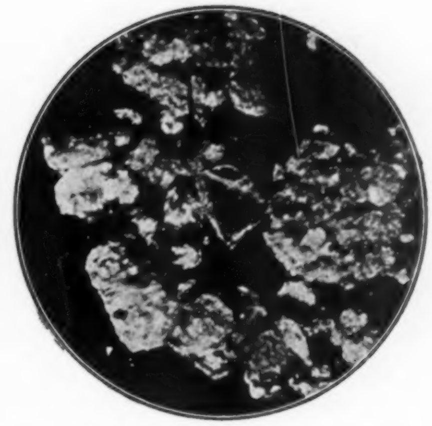

Fig. 3 Impurities in Micaceous Graphite (120 Diameters)

A STUDY OF GRAPHITE AND OF ITS COMPOUNDS FOR LUBRICATING PURPOSES

By CHRISTOPHER H. BIERBAUM,[1] BUFFALO, N. Y.

Member of the Society

MAN'S earliest knowledge of graphite dates back to the remotest antiquities, its application for useful purposes being shown in the prehistoric remains on continental Europe. Here it had been used not only as a coloring material in the early art of pottery making, but also mixed with clay for making refractory melting pots or crucibles.

The earliest written history of graphite seems rather indefinite, leaving considerable doubt in some instances as to whether graphite was actually referred to or some other mineral substance. This was due entirely to a lack of exact chemical knowledge, which resulted in confusing graphite with lead and molybdenite and gave rise to the terms—still modern—plumbago, black lead, *reisblei, crayon noir,* and the like.

The first positive and definite written accounts of graphite and its uses for refractory melting pots are given by Agricola (1494-1555). The next definite economic use of graphite of which we have written history is in the lead pencil, made as far back as the sixteenth century by placing a carefully shaped piece of natural graphite into a grooved wooden stick. It may never be known who first used graphite for lubrication in modern machinery, though bearing troubles in the modern sense could not have existed until after modern machinery existed. Statistics show that the number of users of graphite for lubricating purposes is increasing at an enormous rate, the consumption for this purpose for the latest year for which we have data, namely, 1913, being 30,000 tons.

Early in the writer's experience with bearings and lubricating problems, graphite proved an inviting subject. The results obtained, however, were so varied and at times so unsatisfactory that he was finally led to investigate broadly the entire subject of graphite for lubrication, which resulted in perfecting a process by means of which more than thirteen per cent of earthy materials have been eliminated from one of the best-known graphites on the market.

Graphite is one of the three allotropic forms of the chemical element carbon, amorphous carbon—say, the charcoal made of pure sugar—and the diamond being the other two. All three forms are subject to a large number and variety of impurities. It is the impurities of a graphite that largely determine its physical characteristics, and, strange as it may seem, graphite is a material whose impurities give it its designation.

The origin of graphite is twofold—natural and artificial. Artificial graphite is a by-product of the electric furnace in the production of silicon carbide, which is known in the trade as carborundum and crystolon. Natural graphite is derived from coal or early vegetable forms, and from bituminous sources. The gradual process in which Nature has produced graphite from the vegetation of the Carboniferous Age is distinctly seen in the successive steps in the development of the coal formations—peat, lignite, semi-bituminous, bituminous, semi-anthracite, anthracite, and finally graphite itself, having all the impurities corresponding to the admixture of earthy matter during the entire development. The natural graphite of vegetable origin is that generally known as natural amorphous graphite. This is usually a high grade of graphite, that is, the carbon is usually very completely graphitized and free from the high hydrocarbons, but has very decided drawbacks owing to its impurities, consisting mostly of earthy admixtures. The other class of natural graphite is that formed of asphaltic or bituminous matter. The best examples of this class are the Ceylon grades, many of which are known as crystalline or columnar—sometimes called fibrous graphites. In addition to earthy impurities, this graphite also contains some of the very highest orders of the hydrocarbon compounds. The affinity that hydrogen has for carbon is very strikingly shown in these graphite formations: the conversion of the carbon to graphite seems complete and the hydrogen is still held in combination, at least in part. In fact, one of the world's greatest diamond experts finds that the Brazilian

Presented at a meeting of the Buffalo Section of The American Society of Mechanical Engineers, October 29, 1916.

[1] Chairman of the Sub-Committee on Bearing Metals of the Research Committee and Vice-President of the Lumen Bearing Co.

FIG. 4 ABRASIONS MADE BY IMPURITIES (120 DIAMETERS)

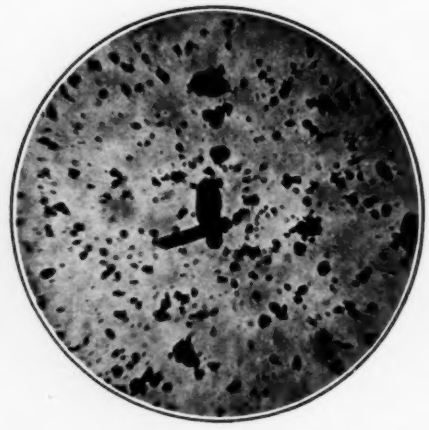

FIG. 5 ARTIFICIAL GRAPHITE SHOWING SILICON CARBIDE (120 DIAMETERS)

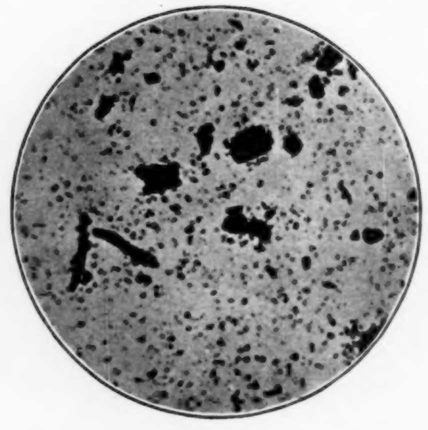

FIG. 6 ARTIFICIAL GRAPHITE SHOWING SILICON CARBIDE (120 DIAMETERS)

diamond still possesses a small percentage of hydrogen and that its specific luster is due to this impurity. To the latter class of natural graphites, those of bituminous origin, belong the micaceous graphites, those formations in which the flakes are made up of alternate layers of mica and graphite; and also those having sufficient micaceous material to impart to the graphite the crystallized structure corresponding to the different varieties of mica.

It will be observed that the usual classification is not adhered to—that the micaceous graphite is not included in the crystalline variety. The reasons for this classification are as follows:

1 Some of the very finest microscopic subdivisions of the coarsely laminated micaceous varieties appear to be amorphous
2 All varieties of the micaceous graphites when ground to ultramicroscopic fineness show transparent particles of mica
3 There is a clear dividing line between the micaceous and non-micaceous graphites of bituminous or non-organic origin.

The characteristic difference between two of the natural graphites, the amorphous and crystalline, is shown in Fig. 1. The right-hand side represents the amorphous graphite and the left side the crystalline. They are substantially of the same degree of purity, one—the amorphous—having more or less irregular rounded particles, while the other has sharp and angular particles. This holds true even though the particles are reduced to the minutest microscopic subdivisions. According to the foregoing classification the strictly crystalline graphites, not being suited for lubrication, are not given further consideration.

Fig. 2 shows a very beautiful specimen, a sliver or transverse section of the micaceous variety of graphite (magnified 200 diameters), in which are seen the alternating layers of mica and graphite, the mica being translucent or light colored and the graphite black or strictly opaque. This striated oblong particle shows a small portion broken off from the main body but still held by a filament of mica which has been bent, showing that the mica is of the flexible variety. This, together with the lines of fracture shown under the microscope, indicates that this particular mica is the variety known as muscovite, a comparatively tough and flexible variety. This specimen has rather coarse laminations, corresponding to the largest flake formation, the layers of mica approaching a thickness of 0.0001 in. Anyone can appreciate that graphite having this amount of mica as an impurity is undesirable in bearings. To illustrate, if one of these particles should become located between an engine shaft and its babbitt bearing over night, the inevitable result would be "pockmarking."

Fig. 3, a photomicrograph, shows the impurities taken from one of the highest grades of micaceous or flake graphite procurable on the market. It shows a number of crystals of abrasive material and other particles composed of mica, clay, alumina, hornblende, and the like. A simple method of testing the abrasive properties of these impurities was resorted to: it consisted in placing a small soft-wood block on the

FIG. 7 ABRASIONS MADE BY SILICON CARBIDE (120 DIAMETERS)

FIG. 8 ABRASIONS MADE BY SILICON CARBIDE (120 DIAMETERS)

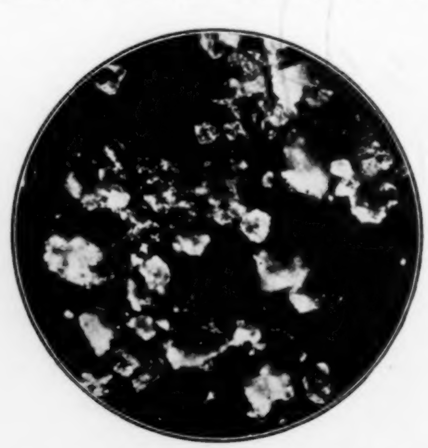

FIG. 9 IMPURITIES IN AIR-FLOATED GRAPHITE (120 DIAMETERS)

FIG. 10 ABRASIONS MADE BY IMPURITIES IN AIR-FLOATED GRAPHITE (120 DIAMETERS)

FIG. 11 MILLED BRONZE SURFACE (100 DIAMETERS)

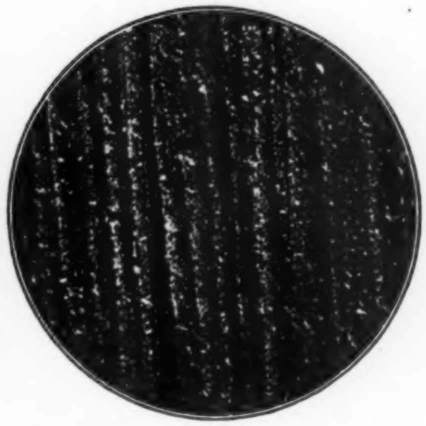

FIG. 12 SURFACE SHOWN IN FIG. 11 ABRADED BY THE IMPURITIES IN AIR-FLOATED GRAPHITE (100 DIAMETERS)

end of a small fan-motor shaft, then mixing the impurities with oil and applying the mixture to the end of this wooden block, holding a microscopic slide against the block while it was revolving rapidly, and then making a photomicrograph of the abraded microscopic slide, using oblique illumination. Fig. 4 shows this abraded surface. It will be appreciated that in all of these abrading tests only those particles which are hard enough to cut glass have been brought into consideration, since all particles hard enough to cut glass are also hard enough to cut any bearing for which graphite might be used as a lubricant, whether it be a babbitt, bronze, or hardened-steel roller or ball bearing.

Artificial graphite is an amorphous graphite, as is clearly shown in Fig. 5. As already stated, it is a by-product of the electric furnace in the manufacture of silicon carbide—next to the diamond the hardest known abrasive substance—and it is difficult to remove all traces of this matter from the graphite. In the center of the view is shown a small spicule of this material, so undesirable in a lubricant. Fig. 6 likewise shows a pair of silicon-carbide crystals.

Fig. 7 is a photomicrograph of a glass surface abraded in the manner already described by using artificial graphite which had been marketed in the dry form. It is interesting to note the sharp, definite cuts in this view, characteristic of a high-class abrasive.

Fig. 8 shows an abraded surface made with an artificial-graphite compound marketed in the form of a graphite grease. Fig. 9 shows the impurities of an amorphous natural graphite. These impurities are somewhat clotted together, though sharp and distinct crystals—mostly silica or white sand—are discernible. It will be observed that these crystals are more or less rounded, and Fig. 10 shows a surface abraded by matter resembling sea sand, but not in as clear-cut a manner as in the preceding figures.

It has sometimes been argued that the impurities of graphite could be counteracted by simply using a larger amount of graphite, just as an excess quantity of oil or grease is supplied when the quality is deficient. This, however, cannot be done with graphite. The following two photomicrographs (magnified 100 diameters) show that any abrasive impurity whatever cannot be present in the graphite without leaving its undesirable or destructive effect upon the bearing surfaces. Fig. 11 shows the smooth-milled surface of a bronze gear tooth of a rotary pressure pump which was used for pumping a mixture of substantially equal parts of water and fine air-floated graphite, the mixture having the consistency of cream. The pump was used for pumping this mixture against a head of 2 lb. per sq. in. for the purpose of forcing the graphite and water through a burr mill in order to effect proper grinding. Fig. 12 shows the surface of this tooth after it had been in use for thirty days, and demonstrates very conclusively that it is impossible to use graphite with impurities in any form between metallic wearing surfaces without having the injurious abrasive effects of these impurities.

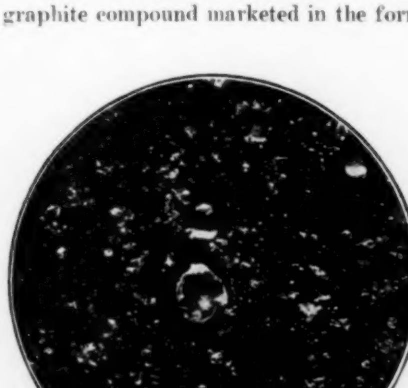

FIG. 13 IMPURITIES IN AIR-FLOATED GRAPHITE (100 DIAMETERS)

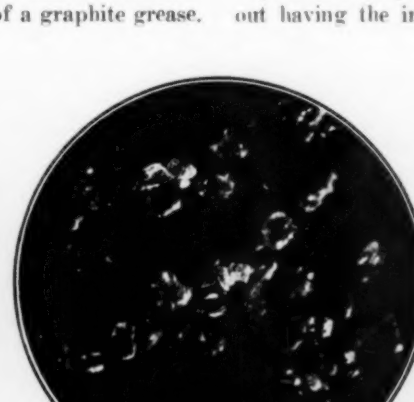

FIG. 14 IMPURITIES IN AIR-FLOATED GRAPHITE (120 DIAMETERS)

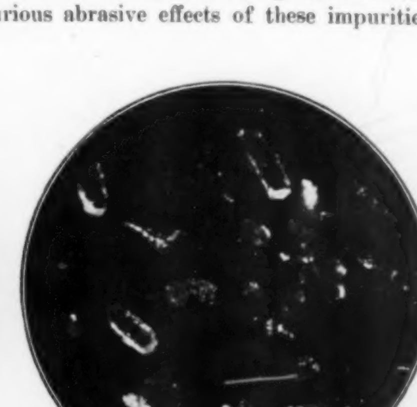

FIG. 15 IMPURITIES IN AIR-FLOATED GRAPHITE (120 DIAMETERS)

FIG. 16 ABRASIONS MADE BY IMPURITIES IN AIR-FLOATED GRAPHITE (120 DIAMETERS)

Fig. 13 shows the impurities separated out from the graphite-water mixture passing through the pump mentioned, also magnified 100 diameters.

Fig. 14 shows the washed crystals of another natural amorphous graphite of a very high-grade variety. While this graphite was prepared with the greatest care before marketing, the purifying process being that of air floating, it nevertheless contained a very fine-grained clear sand.

Fig. 15 shows the impurities of another variety of air-floated graphite on the market which are of a somewhat different nature, being more oblong or elongated crystals. This is due to the nature of the composition of these impurities, which are crystallized aluminum oxide. If we had these impurities in their natural colors they would represent jewels, the blues being sapphires, the yellow and canary-colored ones oriental topazes, and the whites leucosapphires. Fig. 16 shows an abraded surface made by the impurities shown in the preceding figure.

Fig. 17 shows a microscopic scale consisting of a very fine graduation on a glass surface, the smallest subdivision being 0.01 mm. (about 0.0004 in.). This scale was subjected to the abrasive test previously described, the graphite used on the small revolving block being that from which the impurities had been removed by the Bierbaum process. The surface of this slide speaks for itself—there was no abrasion, and it can be appreciated that the slightest abrasive particle on this finely graduated surface would have left its mark.

Fig. 18 shows a fungus growth in a graphite compound purchased on the market, and evidences the fact that a vegetable or animal oil was used, at least in part, in its preparation.

Fig. 19 shows the developing spore of another variety of fungus also growing in this graphite compound, and Fig. 20 still another species entering into the decomposition of the oil while it is in the process of becoming rancid.

Fig. 21 shows the fatty acid crystals in the decomposed oil. All animal and vegetable oils, chemically speaking, are salts, glycerine being the base and the acids being the organic radicals corresponding to the chemical composition of these oils. This decomposition cannot and does not occur in pure mineral oils. Graphite compounds using animal or vegetable oils should be thoroughly sterilized before they are sealed in their containers.

It has always been found difficult to apply the dry graphite to an ordinary bearing, and for that reason grease or oil has been chosen as a carrier. In the case of grease there is no difficulty—the graphite will not settle out, but in the case of oil it has given rise to the interesting study of graphite suspension. Anyone who has observed the suspension of dust in the air as revealed by a small beam of bright sunlight entering a dark room must be forced to the conclusion that this suspension of material particles in the air, that is, solid matter suspended in a gaseous medium, is due entirely to the extreme fineness of the particles, since it is observable in air which for days has been in a quiescent state. The suspension

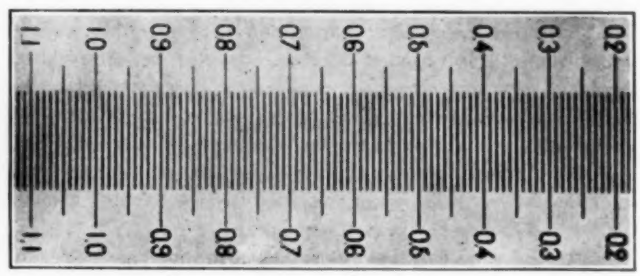

FIG. 17 MICROSCOPIC GLASS SCALE AFTER ABRASIVE TEST WITH PURIFIED GRAPHITE

of a solid in a fluid should therefore be more easily obtainable, especially when we consider graphite and oil, since there is a film tension of oil around each particle of graphite and the oil has a positive capillary affinity with the surface of the graphite, and by the fine subdivision of the graphite its aggregate surface is increased enormously. To illustrate, if it were possible to crush a 1-in. cube of graphite to such a state of fineness that its largest particle would not exceed 0.000001 in. in diameter, the aggregate surface area of this quantity of graphite would then exceed 1 acre, whereas its

FIG. 18 FUNGUS IN RANCID OIL (900 DIAMETERS)

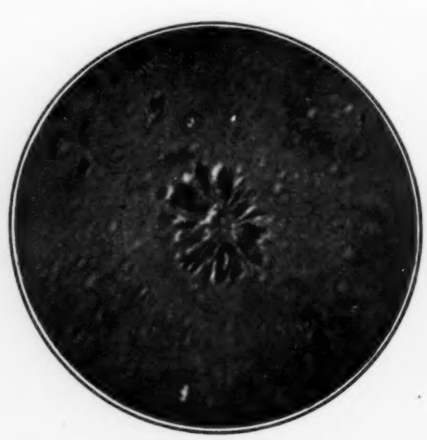

FIG. 19 FUNGUS IN RANCID OIL (900 DIAMETERS)

FIG. 20 FUNGUS IN RANCID OIL (900 DIAMETERS)

original surface area was but 6 sq. in. Such an extreme degree of fineness, however, is not necessary in order to bring the graphite out of reach of the action of gravity when mixed with a light mineral lubricating oil; in fact, microscopic observations seem to indicate that particles 1/200,000 in. in diameter are beyond the reach of the action of gravity.

It may be of interest to express the results of subdivisions mathematically and for the purpose start with an inch cube and consider the successive subdivisions in decimal order. The first subdivision gives cubes of one-tenth inch, the second hundredths, the third thousandths, and so on. Now, let A represent in numerical value the length of an edge of a cube, and we have for the successive subdivisions: A^{-3} the number of cubes, $6A^{-1}$ the aggregate surfaces of any subdivision, $6A^{-2}$ the surface of a single cube, and A^{-3} the weight of a single cube. As the subdivision is increased the weight of the particles is decreased and the relative surface increased, lessening the weight of a particle and increasing capillary affinity, and the ratio of these two values in any subdivision gives the specific buoyancy for that subdivision; that is, $6A^{-2}/A^{-3} = 6A^{-1}$; and omitting the common factor 6 we have A^{-1} for the specific buoyancy, which, from the accompanying tabulation of results, is seen to increase directly in proportion to the increased subdivision.

Fig. 21 Fatty Acid Crystals in Decomposing Oil (900 Diameters)

Fig. 22 is a graphic representation showing the law of increase of surface corresponding to an increased subdivision. Of necessity, only a limited part of the curve is given, still it shows that the curve is hyperbolic and asymptotic to the X-axis and that an infinite subdivision gives an infinite amount of surface.

From a purely mechanical viewpoint the suspension of graphite in oil should be a relatively simple matter; unfortunately, however, when the particles of graphite are fine enough to be able to defy the force of gravity, they are then subject to another force known as the Brownian movements. Under the latter force the graphite particles are subject to what approaches perpetual motion; it is not a continued movement in one direction, but a zigzag course, caused by the free electrons striking the particles of graphite. A particle on being struck starts with a jerky movement and continues moving until arrested by the fluid friction of the oil, provided it has not already been struck by another electron causing it to bound off in another direction. An observer who saw this fascinating action for the first time expressed himself to

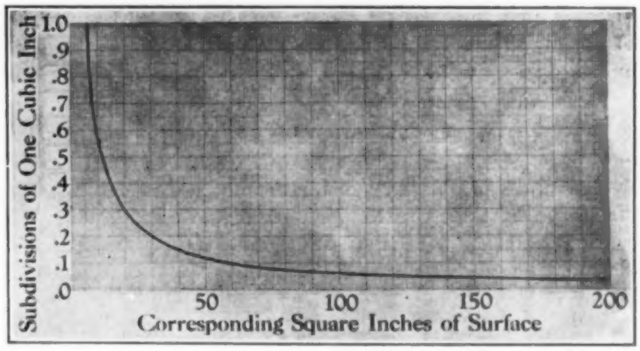

Fig. 22 Curve Showing Increase of Surface with Increased Subdivision

the effect that the particles seemed to be on a St. Vitus dance. During these erratic movements the particles of graphite collide with each other and as a result adhere; they in turn are struck by other particles, and in this manner there is gradually built up a mass of adhering particles which is subject to the action of gravity and results in settling out.

Size of cube, A	Number of cubes, A^{-3}	Aggregate surface, $6A^{-1}$	Surface of single cubes, $6A^{-2}$	Weight of single cube, A^{-3}	Specific buoyancy, A^{-1}
1.	1	6	6	1	1
0.1	10^3	6×10	6×10^{-2}	10^{-3}	10
0.01	10^6	6×10^2	6×10^{-4}	10^{-6}	10^2
0.001	10^9	6×10^3	6×10^{-6}	10^{-9}	10^3
0.0001	10^{12}	6×10^4	6×10^{-8}	10^{-12}	10^4
0.00001	10^{15}	6×10^5	6×10^{-10}	10^{-15}	10^5
0.000001	10^{18}	6×10^6	6×10^{-12}	10^{-18}	10^6

It is obvious, from what has gone before, that the greater the number of free electrons present in the oil, the more rapidly the coagulation and settling-out process should proceed, and such is the case. It is fully borne out by experience that the addition of a free acid or salt greatly accelerates the precipitation; in fact, any electrolyte present has this effect, such as the acid residue or its resultant neutralized salt re-

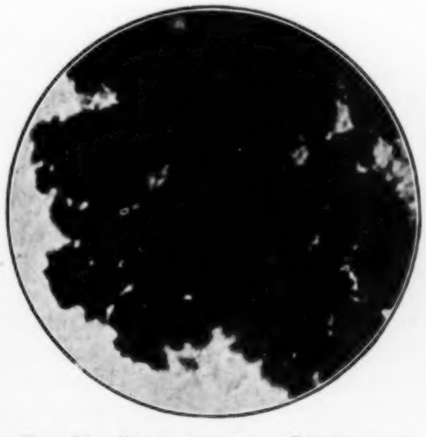

Fig. 23 Coagulation of Graphite in Oil (1200 Diameters)

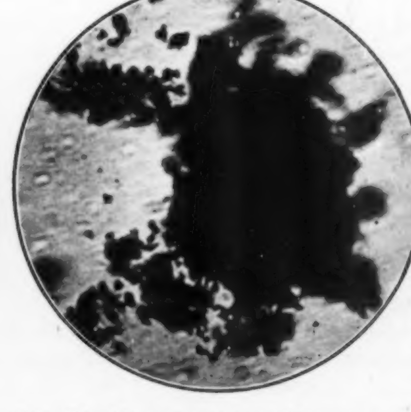

Fig. 24 Coagulation of Graphite in Oil (1600 Diameters)

maining in a lubricating oil after refining, or the rancidity of an oil, all tending to increase the number of free electrons and the precipitation of the fine particles of graphite.

Various expedients have been resorted to in order to effect so-called permanent suspension of graphite in oil. The one most commonly made use of is that of coating the finely ground particles with a foreign substance and then effecting a high dispersion of these coated particles throughout the oil. The coating material is usually a vegetable compound; if an oil it should be one insoluble in the mineral oils, such as castor oil, or it may be tannic acid or an allied tannin compound. Fig. 23 shows the precipitation of a commercial variety of oil-coated suspended graphite. Fig. 24 shows one more highly magnified, it being the precipitation of a commercial variety of tannin-coated suspended graphite, the largest particles of which do not exceed 1/250,000 in. in diameter.

The value of a so-called permanent suspension of graphite in oil is more fanciful than real, for the reason that in all such attempts the graphite is ground to such an extreme degree of fineness that this very fineness mitigates against its being useful. In a bearing properly constructed, lubricated and in operation the bearing surfaces are completely separated by the oil film and the extremely fine particles of graphite simply float in the film, exerting no appreciable effect either beneficial or otherwise.

The time, however, when graphite can be of benefit and perform its only and supreme function is when the oil film between the bearing surfaces is destroyed and the graphite serves as a solid lubricant. The graphite is carried between the bearing surfaces by the oil, and in the same manner, when the oil film is destroyed by being squeezed out, the graphite particles are carried along with the oil from between the bearing surfaces until the film is reduced to a thickness corresponding to the dimensions of the largest particles of graphite which at this stage will be arrested and held between the surfaces. Upon the complete destruction of the film these particles so held are crushed and imbedded into the grain and pores of the surfaces and thus are made to perform their function of solid lubrication. It is evident that the smaller the particles are, the less will be the amount of graphite so intercepted between the bearing surfaces; therefore, a given amount of graphite is most efficient if it exists in particles of the largest possible size. The more nearly permanent a graphite suspension is, the more nearly does it approach the colloidal state and the more completely is it carried out from between the bearing surfaces when the oil film is being destroyed.

This can be demonstrated in a most striking manner by taking a light-colored lubricating oil, thoroughly mixing with it a definite amount of graphite, and then placing it between two highly accurate glass surfaces and observing the amount of color left after a definite pressure has been applied for a definite time, while maintaining a fixed temperature. An amorphous natural graphite ground so that its coarsest particles did not exceed 0.0002 in. showed under the foregoing conditions an almost opaque surface, while a commercial graphite suspended in tannin and whose largest particles did not exceed 1/250,000 in., showed a substantially colorless surface. This is readily accounted for by the fact that the largest particles in the one graphite contained 125,000 times the bulk of those in the other, a condition existing at the time the glass surfaces in each case had approached each other near enough to arrest the flow of the respective particles.

The carbon content of graphite is not an indication of its lubricating value or its purity, for the reason that the percentage of amorphous carbon in some varieties is comparatively high. Amorphous carbon, or carbon not completely graphitized, can best be classed as an inert impurity; its presence always shows extreme blackness. The same is true of another common impurity, hydrogen, or a hydrocarbon; this is also black, whereas the purest graphite is a dark steel-gray when mixed with a clear white oil. The chemical laboratory can only give valuable information on the subject of the graphites when the work is done by an expert or specialist.

Advisory Committee for Aeronautics

THE report of the Advisory Committee for Aeronautics (British) for the year 1916-1917 has just been issued. Following the rule of the immediately preceding years, it omits the technical appendices which in peace time were the principal and most interesting parts of the reports.

Strength of Construction. A number of questions relating to strength of construction have been investigated, and some general conclusions have been reached tending to simplification of strength calculations. The basis is to be adopted in design to secure adequate strength in high-speed machines, with the power to rapid maneuvering essential in aerial fighting, is a matter demanding the most careful consideration. To secure the highest possible speed it is necessary to keep down the weight to a minimum, and the best compromise between these two opposed conditions does not admit of precise determination. This question has received attention, and the manner in which strength varies with increase of dimensions has also been made the subject of investigation. Cases in which vibration has been set up have been examined, and calculations relating to the strength of the body structure have been made.

Engines. A number of questions relating to engines and engine design have been submitted by the Air Board for consideration by the Engine Sub-Committee. These have required very careful investigation, and the sub-committee has been closely occupied since its formation with the various problems which have arisen. Experimental work has been carried out, by request of the sub-committee, at the Royal Aircraft Factory; and the sub-committee has received much assistance in the examination of special questions both from manufacturing firms whose works have been visited.

Light Alloys. The use of light alloys in the construction of aircraft and aircraft engines is becoming of rapidly increasing importance, and improvements in the production of light alloys will have great effect on future development. The investigations relating to light alloys which have been in progress for many years at the National Physical Laboratory have been continued, and results of special interest have been achieved during the past year. Suggestions have been made to the Air Board by the Committee which may, it is hoped, help to secure the best conditions in manufacture for the development of such alloys. The formation of the Light Alloys Sub-committee will be of great assistance in coördinating the work on light alloys which is being done in various quarters, and in collecting the information resulting from experimental investigation and manufacturing experience. Experimental work has been carried out for the sub-committee at the Royal Aircraft Factory, the University of Birmingham, the National Physical Laboratory, and elsewhere, and arrangements have been made for placing the information obtained at the disposal of manufacturers.

Other subjects treated in the report are: Experimental work in aerodynamics; fabrics, dopes, etc., and investigations relating to seaplanes.

SYMPOSIUM ON STEAM LOCOMOTIVES HELD BY THE MINNESOTA SECTION

A SYMPOSIUM on steam locomotives was held by the Minnesota Section of the Society on the afternoon and evening of March 10, 1917, at the Main Engineering Building of the University of Minnesota. Seven papers were presented, as well as a discussion on Metal Alloys Used in Locomotives, by Prof. G. L. Hoyt, and a short address by Dr. Ira N. Hollis, President Am.Soc.M.E. J. V. Martenis, Mem.Am.Soc.M.E., opened the afternoon session with an address on the Historical Development of the Locomotive, which was profusely illustrated with lantern slides and later illuminatingly discussed at some length by J. J. Flather, Mem.Am.Soc.M.E. Papers were then read which had been prepared by Messers. Foque, Toltz, Bourne, Muhlfeld, Ostermann, and Basford, extended abstracts of which immediately follow.

MODERN LOCOMOTIVE PRACTICE

By T. A. FOQUE, MINNEAPOLIS, MINN.

Member of the Society

IN passenger service the locomotive best suited to present-day requirements is the 4-6-2, or Pacific type, which is almost universally used where a tractive effort of from 42,000 to 45,000 lb. is required. Where very heavy grades are encountered, or where long, heavy trains are operated on even moderate grades, the 4-8-2, or Mountain type of locomotive, is becoming popular.

In freight service the 2-8-2, or Mikado type, is now largely used in place of the 2-8-0, or Consolidation engine, where a tractive effort of from 50,000 to 60,000 lb. is required. With a 63-in. driving wheel it is not only good for heavy freight service, but is well adapted to fast freight work. On lines with very heavy grades this type of engine, with the addition of a fifth pair of driving wheels, is designed for a tractive effort of from 65,000 to 83,000 lb. and is known as the Santa Fe type. Increased boiler capacity and factor of adhesion make this type of engine better for heavy slow service than the Mikado type.

On exceptionally heavy grades, extending over a large portion of a division, Mallet compound engines are quite generally used in 2-8-8-0 and 2-8-8-2 types. The tractive effort of existing engines runs from 91,000 to 103,000 lb.

For pusher service over heavy grades triple-compound types, 2-8-8-8-2 and 2-8-8-8-4, are now being used by two railroads. These have two high-pressure and four low-pressure cylinders, and the rear set of driving wheels and truck are located under the tender.

One road is now experimenting with a 2-8-2-2-6 type of engine, consisting of the application of the running gear and machinery from a retired Mogul locomotive to the tender of an existing Mikado locomotive.

In switching service the ordinary or 0-6-0 type is in most common use, but some 0-8-8-0 Mallets with a tractive effort of 100,000 lb. are now being used in hump-type classification yards. Considerable time is saved on account of taking trains just as delivered by road engines and putting them over the hump and classifying. For heavy general switching service the 0-8-0 type, running up to 70,000 lb. tractive effort, is used with success.

Comparative few locomotives are now built without a superheater. The economy following the use of this device is very marked and existing engines have been greatly improved by the addition of the device. To reduce the fuel consumption further the use of brick arches supported on water tubes is very common, and modern improvements in the design of the arches have made their use practical where formerly they gave considerable trouble.

On all road locomotives and some switching locomotives, outside valve gear of the Walschaerts type is used almost altogether. Accessibility, better distribution of steam and freedom from breakdowns make outside gear very desirable. On the Soo Line we have modified the ordinary type of gear by taking our motion for the lap-and-lead lever from the main rod instead of the crosshead. This is quite a marked improvement in that it gives us much better port openings.

The majority of engines now built are so heavy that the usual form of reversing mechanism is not suitable, and power reverse gear, either of the screw pattern or operated by steam, has been introduced with very satisfactory results.

Pneumatic fire doors relieve the fireman of much work and are beneficial to an engine in that they greatly reduce the time in which a door is kept open.

One of the great troubles with heavy locomotives is found in the design of the main driving boxes, and the brass in the ordinary type of box may be renewed two or three times before an engine requires a general shopping. To eliminate this expense and wear on an engine, boxes 20 in. long or longer are now used on the main journals.

The old practice of keeping steam pipes within the smokebox has nearly been done away with, and we now use outside pipes to the steam chest, eliminating in a large measure the trouble with leaky joints and giving us easier access to the smokebox appliances.

The advent of long freight trains called for air compressors of much greater capacity, and we now use two single-stage pumps or one compound pump.

In recent years much more attention has been given to proper air openings in the ashpans and dumping mechanisms which will allow of frequent and easy disposal of the cinders. On some large locomotives, especially where a low grade of fuel is used, the work of firing has become too much for one man and mechanical stokers are now being used, and some of them are now doing very good work.

Within a year or two a few roads have experimented with an apparatus for burning pulverized fuel. The question is one of much interest, for there are in certain parts of the country large deposits of fuel wholly unsuited to locomotive use in its present form, but which may in powdered form prove not only satisfactory but very economical.

In locomotive tenders the tendency today is toward those of large capacity, which frequently permits of the avoidance of water supplies which are exceedingly bad. To save labor and because of legislation, tenders are now constructed with coal hoppers of such design that the coal will automatically be placed within easy reach of the fireman. Hoppers which cause the coal to come down and forward by gravity are the cheapest and best, but in some cases mechanical coal pushers have been installed.

Special attention has been given for a number of years to truck design, with a view to eliminating dangerous roll at high

speeds. In many derailments the forward tender truck is the first to leave the track. Comparatively slight depressions in the track may set up a rolling of the tender, which, accompanied by a reverse roll of the locomotive, will cause the forward tender wheels to jump. The connections between the locomotive and tender also have a bearing on this, and one connection has been designed which is a vast improvement over anything used before.

Important as is the design and construction of a locomotive, the vast majority of troubles in locomotive operation may be found in lack of maintenance. In certain parts of the country we are sorely tried with water heavy with incrusting salts. It is not an easy matter to handle bad water successfully, but in most cases it can be done. In repairs to machinery there is but one sensible and economical course to follow: when defects appear, apply the remedy. It has been demonstrated without question that it is more economical to keep up the running repairs and not wait until a locomotive needs a general shopping.

THE LOCOMOTIVE OF TODAY

By MAX TOLTZ, ST. PAUL, MINN.

Member of the Society

The steam locomotive is a power plant which has to be admired, because if the same amount of power is developed in a stationary plant it will take up from five to ten times the amount of space. Modern large locomotives are developing now as high as 3000 hp., with a drawbar pull of very nearly 105,000 lb.

Ten years ago wide fireboxes were already used to a considerable extent, also brick arches supported by water tubes. Moreover, extra water tubes were added in the firebox to improve the water circulation and to increase the heating surface of the boiler.

The Walschaerts valve gear succeeded the Stephenson not because the Walschaerts gives the better steam distribution but because it facilitates the strengthening of the frame of the locomotive. The use of metal alloys has also been introduced for the purpose of strengthening parts of the locomotive.

In 1905 the writer pointed out that in applying superheaters to locomotives a high superheat should be employed to obtain economy in water and coal consumption. At that time it was the general consensus that 100 deg. of superheat would be all that was necessary for this purpose.

In 1906 he applied the first Schmidt fire-tube superheater to the locomotives in the States. Not less than 250 deg. of superheat were obtained, which resulted in an average saving of 25 per cent of coal and 35 per cent of water. Since 1908 or 1909 the fire-tube superheater has come to stay with us.

To improve the combustion and at the same time to force the capacity of the locomotive boilers by burning more coal per square foot of grate surface, automatic stokers have been applied to locomotives with great success. The present stoker has given good satisfaction, yet the combustion of coal can still be improved and is being improved by the adoption of pulverized coal on locomotives. Although the latter is in an experimental stage at present, there is no doubt but that it will be a success.

Another improvement on the locomotive, which will no doubt be perfected, is the heating of the feedwater, either with the waste gases or with the exhaust steam.

If we compare the economy of the locomotive of twenty years ago with that of the locomotive of today we know that we are getting over 50 per cent more work than we did then. Yet we should not be satisfied with this, but should strive to make the locomotive a power plant second to none.

METAL ALLOYS USED IN LOCOMOTIVES

By G. L. Hoyt[1]

Every railroad man who is concerned with the design of a locomotive knows that heat-treated steel has better properties than annealed, for by heat treatment we are able to produce certain properties that can be produced in no other way. I have found out, however, in talking with various railroad men, that the chief reason why they are not ready to adopt heat-treated parts is that heat-treated steels do not stand up any better than ordinary carbon steels, and that in some cases special steels give more trouble than ordinary carbon steels. The reason given is that the producers of these parts are not in a position to heat-treat material of that quality on a commercial basis to sell for such a price that the railroads can effect an economy in buying. The practice at present seems to by merely to anneal these various parts. A locomotive axle will be forged out, the steel used being the ordinary good grade of open-hearth steel; it is then heated up to the critical point and air-cooled down slowly. The object, I take it, is to insure uniformity and absence of internal strains. Whether or not a satisfactory structure is produced is of entirely secondary importance. When I mention internal strains, I hit the nail on the head as to why heat-treated steels are not used generally in locomotive practice. There can be no doubt about the advantages which they possess over ordinary carbon steels, and if it is impossible at present to obtain heat-treated steels for locomotive construction, something should be done about it.

If I can see the signs of the times correctly, there is a necessity for all the economy possible in railroad operation, which is why the question of using heat-treated steels in locomotive construction is becoming more and more important. It is possible to produce steels that far surpass those entering into locomotive construction. In gun construction the United States Government and the steel plants got together and are now successfully manufacturing heat-treated gun parts. Hadfield projectiles are probably the most difficult of all materials made of steel to produce satisfactorily, the internal strain serving to weaken the resistance of the material.

What has been done in other cases can be done in regard to any part about a locomotive. I can see nothing inherently difficult about heat-treating locomotive parts. Whether or not those methods are developed depends upon the demand made upon the steel plants by the railroads to produce the desired material. If the roads feel that there would be an economy in using heat-treated parts, undoubtedly there would be a great attempt on the part of the steel plants to produce that material.

When you are getting a certain grade of steel, you may have certain specifications, but 30 per cent elongation, etc., tell almost nothing about the steel, that is, so far as whether the axle is going to stand up in service, for the tests which are used to bring out the superiority of heat-treated steels are of an entirely different character. Take a locomotive frame, or the axle. Its parts are subjected to vibratory strains and stresses. Say that the locomotive axle runs hot, and that it is cooled off by water, ice, or snow, and a crack is started. What is the effect of the presence of a crack in a locomotive axle, in

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one having a fine-grained structure, and one having a coarse grain? In considering this, the real value of heat treatment is brought out, and something that is not shown by ordinary tensile tests. A crack is of much less consequence in the case of softened steel than in the case of annealed steel. Internal strains are eliminated in annealed steel, but the same treatment which produces the fine-grained structure also eliminates internal strains. It is a question of properly conducting the heat treatment, and the trouble is that the steel plants either work carelessly or for some other reason do not take particular pains to heat-treat the material. If the railroads as a whole would take up this question and push it as they pushed the question of steel rails a few years ago, I have no doubt but that they would be getting properly heat-treated steels.

As far as special steels are concerned, the problem is different. Their cost at present is almost prohibitive. Nickel steels, etc., are now in such demand on account of their use in the manufacture of munitions and automobiles that no considerable portion or amount of them can be diverted to such a use as this, and unless they are heat-treated they are not at all worth the additional cost.

When using special steels which have been heat-treated, why do those in charge of locomotive construction insist on using the same designs? A certain part is made of ordinary carbon steel annealed. As an experiment, a railroad will buy that part made out of special steel, heat-treated, and expect to effect an economy. No metallurgist would advise leaving the design the same: if it is correct for carbon steels, it is not correct for special steel. If you leave the cross-section the same, you leave the weight of the section the same, and the price of the heat-treated part consequently seems exorbitant. The management, however, probably takes the stand that it is better to leave the section the same and get the improvement by substituting a good steel, but this does not give a satisfactory basis for comparison.

Another point I want to bring out is the service you can expect from special steel as compared with carbon steel. A locomotive equipped with special-steel heat-treated parts is usually found in the shops as frequently as other locomotives, but the reason is that the heat treatment has not been carefully done. I am convinced of that when told of the failures of the heat-treated parts.

In closing, let me compare the service of annealed carbon steel with the service of special steel properly treated. The carbon steel is ductile and has a certain amount of strength, but in practically every other way it is weak, and particularly so if a flaw develops. If a small crack starts working its way through the axle, right there the annealed axle is weakest. It is on account of the large percentage of free iron. One of the worst things that could be done for a steel axle from that point of view would be to anneal it, for this would produce the free iron. One thing that counteracts this is the removal of internal strains. A heat-treated steel axle, whether carbon or special, designed so that it will have the same static strength, if injured in any way has several times the resistance of annealed steel. The heat-treated steel is less apt to be tricky than the annealed.

The saving effected by using special steels results chiefly from cutting down the weight of the reciprocating parts; but unless these are designed with the properties of the heat-treated steel in mind, there can be no real comparison drawn. The work done up to the present time does not lead to a reasonable comparison between special and annealed steels, and until that is done properly, we are not in a position to say whether the special steels should be condemned.

SUPERHEATER DEVELOPMENT IN AMERICA

By GEORGE L. BOURNE, NEW YORK, N. Y.

Member of the Society

Of all the devices or improvements which have been introduced in American locomotive practice, the fire-tube superheater is by far the most notable. By its economy in fuel and water it brought the heaviest locomotive well within the capacity of the average fireman. Here was a device exactly suited to American practice—one with a low maintenance cost to fit in with the high wages of American mechanics; with increased boiler capacity of approximately 35 per cent, to act as a reservoir of power, ready for use when most needed; and finally, with a fuel economy of from 20 to 25 per cent.

As a result of the suitability of the superheater to American railroad requirements, there are today over 21,000 superheated locomotives in service or under construction in the United States and Canada. During the past year superheaters were applied to approximately 95 per cent of all the standard-gage steam locomotives built in the United States.

The general trend of superheating engineers has been toward a higher superheat—increasing the gas area available for superheat at the expense of the boiler tubes. This, it is true, tends toward a lower boiler efficiency on account of the necessary loss in water-heating surface, but the resultant increase in the efficiency of the entire machine offsets this many times over.

The results obtained on the Long Island and Lehigh Valley Railroads, which have used steam at a temperature in excess of 750 deg. fahr., have clearly demonstrated the possibilities of higher steam temperatures. As 200 deg. of superheat is amply sufficient to overcome condensation losses in the steam pipes, valves and cylinders, it is evident that the increased efficiency obtained by any superheat in excess of 200 deg. fahr. must be entirely due to increased volume of the steam per unit of weight. This is an almost constant increase in volume for each degree of temperature, and as far as calculations have been worked out for superheated steam, there is no limit to this increase. There can be no doubt that the limit of superheated steam temperatures for the most economical and efficient operation is only fixed by the ability of the exposed machine parts to withstand the higher temperatures.

While superheated steam was originally regarded as of benefit, primarily, to heavy road locomotives using steam for long, continuous periods, later developments have proved its desirability for the more efficient operation of locomotives in all classes of service. Perhaps the most notable example of this tendency is in the superheating of switching locomotives. While the degree of superheat obtained in switching service is naturally not as high as on road engines, it is, nevertheless, enough to reduce condensation losses greatly, which in this class of service amount to over 40 per cent of the total energy developed by the boiler.

As a result, there are today over 1300 switch engines which have been equipped with superheaters, and a steadily greater proportion of the switching locomotives built are being superheated. It is significant in this connection to note that those railroads which have made a trial of superheated switch engines are now foremost in applying superheaters to their existing yard power.

The original design of the fire-tube superheater was so sound that comparatively few changes have been necessary in adapting it to the peculiar requirements of American railroads. But there have been certain modifications which, although of a minor character, are nevertheless worthy of attention.

The first important change was in the redesign of the through-bolt header. Experience showed that the original design gave entire satisfaction when correctly manufactured, but to furnish insurance against inferior material or improper methods in casting, a new design was prepared in order to counteract, as far as possible, the results of possible errors made in manufacture. In the new through-bolt header an additional air space has been provided between the walls of the superheated and saturated compartments in order to protect the casting from the rapid transfer of heat between these compartments, as insurance against the development of cracks between the unit seats in the lower face of the header.

The second great advance was the improvement in the design of the unit return bend. This consisted in producing a welded return bend to replace the original cast-steel bend, with consequent elimination of all mechanical joints in the unit. This machine-forged return bend, which is now almost ready for the market, will have a heat resistance equal at least to that of the old cast-steel return bend. At the same time it will have all the advantages which go with freer steam passages and a minimum restriction to the flow of gases through the superheater flues, with the complete elimination of all leakage due to threaded connections in the unit.

THE USE OF PULVERIZED FUEL ON LOCOMOTIVES

BY JOHN E. MUHLFELD, NEW YORK, N. Y.

Member of the Society

As the limiting factor of a modern steam locomotive is the evaporation and superheat production capacity of the boiler, the rate and effectiveness of the combustion become the controlling elements. While there is no limit to the amount of fuel that may be mechanically supplied to a locomotive firebox, there is a decided limitation to the amount of fuel that can be burned on a given grate area and effectively utilized.

When coal is burned on grates a rate of about 50 lb. of run-of-mine grade,—or about 60 lb. of lump grade of bituminous coal,—is the maximum allowable per sq. ft. of fire surface per hr. for the greatest practical boiler efficiency. However, as this rate of firing limits the consumption to a total of from 3000 to 6000 lb. per hr. for the average modern locomotive of great power, and as the actual coal that must be supplied to the firebox by mechanical stoking in order to maintain the boiler pressure frequently reaches a rate of 150 lb. per sq. ft. of grate area per hr., or a total of from 9000 to 15,000 lb. per hr., the boiler efficiencies often run as low as from 55 to 45 per cent and even less.

The necessity for eliminating grates if much over 12 lb. of water is to be evaporated per sq. ft. of water-heating surface per hr., is therefore quite apparent provided reasonable efficiency is to be obtained, and this brings us to the problem of burning solid fuel in a manner that will overcome the principal deficiencies in the steam locomotive and enable it to maintain its present position in the steam-railway field and to assist further in reducing the high cost of railway living.

As I presented before the 1916 Annual Meeting of the Society an exhaustive report on Pulverized Fuel for Locomotives, which, with the discussion, was abstracted in THE JOURNAL,[1] I will make this paper quite brief.

When solid fuel is burned on grates in a modern locomotive, from 45 to 70 per cent of the heat is absorbed by the boiler. Of that which is wasted the majority is due to incomplete combustion, sparks, cinders, smokebox gases and combustible in the ash. Owing to the necessarily limited grate area, the high draft essential to induce sufficient air through the grates for combustion causes these enormous losses through unburned gases and fuel that are exhausted from the stack or carried into the smokebox and ashpan.

Generally speaking, it is necessary to break up any fuel to such uniform size that the oxygen in the air can unite perfectly for combustion. A deficiency in this respect results in some portions of the fuel passing off as unburned hydrocarbons, and other portions being left as incompletely burned coke. For the best results coal should be sized to about 3-in. cubes for burning on locomotive grates, but as this is now quit impracticable, due to the methods of mining and the cost, a mixture of fine and large coal is usually supplied, which tends to burn irregularly and results in a reduction of boiler capacity and efficiency.

As a 1-in. cube of coal exposes but 6 sq. in. of area for absorbing oxygen and liberating heat, but when pulverized to the proper fineness will expose from 20 to 25 sq. ft., the first essential for complete combustion is the breaking up of the fuel into dry minute and uniform particles. Then, by diffusing these so that each may be surrounded with the right quantity of air for complete combustion, it will be possible to burn practically all of the available combustible, regardless of the percentage of non-combustible.

Any solid fuel that, in a dry pulverized form, has two-thirds of its content combustible, is suitable for pulverizing, and to produce the best results should be mechanically dried and milled so that it will be of about the same dryness and fineness as portland cement. The total cost to prepare pulverized fuel properly in a suitably equipped plant will range from 15 to 45 cents per ton, and for a railway coaling station of average capacity will be less than 25 cents per ton.

In the process of burning pulverized fuel the fuel in the enclosed tank gravitates to the conveyor screws which carry it to the fuel and pressure-air feeders where it commingles with the air. It is then blown through the connecting hose to the fuel- and air-delivery nozzles and blown into the burners. Additional air is supplied and the mixture is drawn into the firebox by the front-end draft. Additional air is supplied in the furnace where complete combustion of the fuel in suspension takes place. The liquid ash runs down the under side of the roof and the sides and ends of the furnace and is precipitated into the self-cleaning slagpan, where it solidifies into a mass that can be readily dumped.

The blower is driven by a constant-speed steam turbine which requires no regulation or control. The fuel conveyors, feeders and comminglers are driven by a variable-speed steam turbine which is controlled by the fireman by means of a handwheel conveniently located in the cab.

The smokebox-gas analysis will average between 13 and 14 per cent of CO_2 when coal is fired at the rate of 3000 lb. per hr.; between 14 and 15 per cent at the rate of 3500 lb. per hr., and between 15 and 16 per cent at the rate of 4000 lb. per hr., so that as the rate of combustion increases there is no falling off in the efficiency, as obtains when coarse coal is fired on the grates.

The waste of fuel from the stack, where coal having a large percentage of dust and slack is used; the lowering of the firebox temperature and draft, due to opening of the fire door; and the resultant variation in steaming and general results under high rates of burning fuel on grates, where all of the foregoing factors are involved, are entirely eliminated.

[1] THE JOURNAL, December 1916, p. 983; January 1917, p. 48; February 1917, p. 141.

The uniformity with which locomotives can be fired is indicated by the fact that the regularly assigned firemen can maintain the steam within a variation of 2 lb. of the maximum allowable pressure, without popping off.

While the smokebox temperatures have varied between 425 and 500 deg. fahr., the superheat in the steam will vary between 200 and 325 deg. fahr., depending upon the rate of working.

With pulverized fuel a locomotive having the boiler filled with cold water may be brought under maximum steam pressure within an hour, and the fuel feed then stopped until it is called for service. When standing or drifting at terminals or on the road the fuel feed can also be discontinued, as the steam pressure can always be quickly raised. After the trip or day's work the locomotive can be immediately stored or housed, the usual ashpit delays being entirely eliminated.

From the actual operation of steam locomotives in regular train service, the use of pulverized fuel has demonstrated in particular the practicability of eliminating smoke, cinders, sparks and fire hazards; increasing drawbar horsepower per hour per unit of weight; reducing non-productive time at terminals; improving the thermal effectiveness of the steam locomotive as a whole; utilizing otherwise unsuitable or waste fuels; eliminating arduous labor; providing greater continuity of service, and producing more effective and economical operation and maintenance.

ECONOMY OF THE LOCOMOTIVE SUPERHEATER

By R. M. OSTERMANN, CHICAGO, ILL.

Member of the Society

In the fire-tube superheater the superheater heating surfaces are interspersed with the evaporating surfaces of the boiler, and a very compact arrangement is thereby created with numerous parallel gas passages, resulting in best utilization of the heat contained in the gas. As a matter of fact, at large loads relatively low smokebox temperatures—that is to say, a high heat absorption of the combination—are readily obtained.

In the locomotive the superheat increases at a nearly constant rate with the indicated horsepower, and varies in a generally similar manner with the draft and the rate of evaporation, both of which are automatically regulated to suit the load by the smokebox exhaust. The superheater is therefore what might be called a "power booster" for the locomotive, and this is a very valuable feature from an operating point of view. The more steam demand there is made upon the boiler—the higher the rate of evaporation, the more intense is the action of the superheater in decreasing the specific steam consumption of the locomotive. The boiler without the superheater does not possess this feature; on the contrary, the priming rather increases the steam rate very fast when the boiler is forced.

The action of the superheater in boosting the steam temperature and power of the locomotive probably finds its limit of benefit when too great an increase of cut-off halts a further reduction of specific steam consumption. Just at what speed and power this takes place naturally depends upon the proportions of the boiler as compared with the cylinders and wheels, and it is a problem of the designer to provide the boiler with its proper share of evaporating and superheater heating surfaces so that the largest possible amount of sustained horsepower can be had at the speed at which the engine is required to operate normally.

In the superheater locomotives that are operated in this country, only part of the tube-sheet area is occupied by the enlarged smoke tubes in which the elements or units of the fire-tube superheater are located. It goes without saying that when an existing locomotive boiler is given a superheater and when, for the purpose of installing the superheater, a part of the tube evaporating surface in the shape of the small smoke tubes has to be removed and enlarged smoke tubes substituted therefor, a certain part of the total evaporating surface must be sacrificed. Given a certain tube-sheet area, the total evaporative heating surface of course increases the smaller the diameter of the smoke tubes selected. That feature is the one which will limit the number of superheater units which can be installed in a given boiler, and with it the capacity of the superheater. The only way in which the capacity of smoke-tube boilers with fire-tube superheaters can be further increased is to subdivide more finely the gas stream to provide a still closer intermingling of superheater and evaporative heating surfaces, for the installation of superheater units of still smaller diameters within smaller smoke tubes. The large smoke tubes which are now used in this country are 5½ in. and 5⅜ in. in outside diameter, with 1½-in. outside-diameter superheater-unit tubes. These dimensions can be successfully reduced, as has been demonstrated on European locomotives and also in power plants of steamboats with Scotch marine boilers.

Substantial savings in coal and water per unit of power developed are now being obtained in every-day operation. As a rough average, a coal saving of 25 per cent and a corresponding water saving of 35 per cent can be expected and thermally accounted for with the knowledge that we have of the average amount of cylinder condensation that exists in saturated-steam locomotives. Inasmuch as the operating value of a locomotive depends upon the maximum amount of horsepower which it can develop, and inasmuch as a great many railroads when they install superheaters are more vitally interested in an increase of the locomotive's capacity than in the fuel saving, it frequently happens that the excess of boiler capacity which becomes available after reducing the specific steam consumption of the engine is reutilized by making greater demands upon the engine's hauling power, that is to say, by lengthening the cut-off or operating it at a higher speed than before it was superheated.

Comparing, then, two locomotives with identically the same engine and wheels, and assuming further that it would be possible to take sufficient horsepower out of the superheater engine in order to make it burn the same quantity of coal as the saturated engine per hour without an appreciable increase of coal consumption per indicated horsepower developed, then, on the basis of the fact that the superheater engine can produce 1 hp-hr. at 25 per cent less fuel than the saturated engine, one can inversely figure that the superheater engine has 33 1-3 per cent more cylinder horsepower and from 45 to 55 per cent more drawbar horsepower than the saturated engine. The superheater engine could, then, haul 45 to 55 per cent more tonnage at the speed of the saturated locomotive, working at a correspondingly larger cut-off. In practice, however, such an increase of tonnage is rarely possible, for the reason that the superheater locomotive has no more starting effort than the saturated locomotive of the same engine dimensions, and particularly on heavy grades the starting feature governs the tonnage that can be handled. An increase in speed, in order to utilize the greater sustained boiler capacity available, is often possible, but hardly ever to the extent that all the excess of boiler capacity potentially existing can be utilized. It can

be taken for granted that part of the benefits of superheating are always reaped in the form of fuel and water saving, and all data from comparative runs, where the superheater locomotive was called upon to develop haulage effort greatly in excess of the saturated locomotive, show a substantial fuel and water saving.

LOCOMOTIVE FEEDWATER HEATING

By GEO. M. BASFORD, NEW YORK, N. Y.
Member of the Society

HEATING the feedwater of a locomotive by heat otherwise wasted is a fairly general practice in all the more progressive European countries, but experiments along these lines have been but spasmodic in this country up to a very recent period. This does not mean that the motive-power officers of American railways are not alive to the possibilities offered in the shape of economy or increased capacity by a practical feedwater heater, but it simply indicates that the tremendous development of the locomotive in this country in the past fifteen or twenty years has made it necessary to neglect many features for the time being which are known to be well worth while. It appears, however, that the time is now about ripe for taking up the subject in a systematic and thorough manner, and a discussion of the principles and possibilities of feedwater heating on locomotives will not be amiss at this time.

The following table gives the general distribution of the heat in a locomotive, and these figures, we believe, are fairly typical of good practice and average results.

Total heat in the coal, per cent		100.0
Loss in unconsumed coal and heat in ashes in the ashpan, per cent	5.3	
Loss in dry smokebox gases and vapor of combustion, per cent	18.0	
Heat through boiler heating surfaces (includes superheater), per cent	76.7	
	100.0	100.0

Investigating further the distribution of the heat after it has entered the steam, it will be seen by the table following that 65.2 per cent of the total heat of the coal is discharged in the exhaust steam, mostly in the form of latent heat.

Heat in steam as shown above (boiler efficiency), per cent	..	76.7
Loss by radiation, per cent	3.5	
Loss in friction of locomotive, per cent	1.0	
Useful work at drawbar (thermal efficiency of locomotive), per cent	7.0	
Heat discharged in exhaust steam, per cent	65.2	
	76.7	76.7

The exhaust steam of course does some work in producing draft and cannot all be considered as a loss, but calculations can be made which will easily show that it is very largely loss and that a small proportion of this heat could perform the work of producing draft satisfactorily.

A locomotive to give the results presented in the above tables would be working at an economical rate, probably burning about 60 lb. of coal per sq. ft. of grate area per hr. Having 76 sq. ft. of grate area and coal of 14,000 B.t.u. heat value, this would make the total heat available in the coal equal 63,840,000 B.t.u. per hr.

As the boiler efficiency is 76.7 per cent, there will be 48,965,280 B.t.u. used to heat, evaporate and superheat the steam. Deducting the amount of heat lost in radiation there will be 46,092,480 B.t.u. in the steam going to the cylinders.

Assuming the feedwater to have a temperature of 60 deg. fahr. and the steam to be at 200 lb. pressure with 200 deg. superheat and the injector to be 100 per cent efficient thermally, about 36,000 lb. of water will be used by the cylinders of this locomotive per hour.

Of the heat going to the cylinders 41,623,680 B.t.u. is discharged up the stack in the exhaust steam. If the steam is exhausted in a dry and saturated state it will then have a pressure of about 5 lb. and a temperature of 228 deg. fahr.

From this brief analysis it is seen that there are 11,461,200 B.t.u. discharged up the stack in the products of combustion, and 41,623,680 B.t.u. in the exhaust steam. The total is 53,084,880 B.t.u. or 83.2 per cent of the total heat of the coal in question.

Necessarily, any part of this heat that is reclaimed and returned to the boiler will allow a reduction by the same amount in the quantity of heat supplied by the coal to produce the same cylinder horsepower.

The most natural and feasible method of collecting part of this waste and again delivering it into the boiler is by using as much of it as is practicable to heat the feedwater before it enters the boiler. All of the heat that can be reclaimed in this way is a net saving.

Two different sources of waste heat are available, viz., exhaust steam and products of combustion or smokebox gases; but because of the size of apparatus and maintenance difficulties in the latter case, it is advisable to absorb all the heat possible from the exhaust steam before attempting to use the hot gases.

A careful study of the experiments that have been made on the heating of water will show that the amount of heat transferred across the unit area will vary greatly with the scouring action of the water as well as the heating medium. In the case of exhaust-steam heaters, however, where it is necessary to condense the heating medium in order to abstract its heat, the problem of a high heat transfer resolves itself largely into obtaining a high rate of agitation of the water. The efficiency of each unit of area will increase as the agitation is increased. Great agitation of the water necessarily implies the employment of energy, and the problem becomes the selection of a suitable form of apparatus which will give the highest rate of agitation of the water with the least cost for power.

One form of apparatus that has been in very successful use and is based on these principles is the Lovekin film heater, which has been applied extensively in marine practice, where the requirements demand minimum size and weight for the greatest efficiency.

In this heater the water is in a thin film between two spirally corrugated copper tubes. See Fig. 1. The heating medium, which is exhaust steam taken from the exhaust passages in the cylinders, is present on the inside of the inner tube and the outside of the outer tube, or on both sides of the water film. The water passing through this tortuous passage acquires a very high rate of agitation, and heat transfers greater than 900 B.t.u. per sq. ft. per hr. per degree average temperature difference are obtainable with a reasonable frictional resistance through the heater.

This design of heater, when arranged for a locomotive using 30,000 lb. of water an hour, forms an apparatus measuring $17\frac{1}{2} \times 21\frac{1}{4}$ in. in section outside and 82 in. in total length. It is easily fitted on the front deck, close to the cylinders, and

under the extension on the front end where it in nowise interferes with any other part of the locomotive and is entirely accessible for inspection or cleaning, if necessary. Fig. 1 shows this heater in section. It has been giving excellent results on a high-speed passenger locomotive during the past seven months, and has shown itself able to heat water from 45 deg. fahr. to 225 deg., or a temperature rise of 180 deg., with an exhaust-steam temperature of 240 deg.

If the conditions assumed for the locomotive above with feedwater temperature of 60 deg. and exhaust-steam temperature of 228 deg. are considered, it will be seen that a temperature rise of 153 deg. can be obtained in the feedwater, or an absorption of 5,508,000 B.t.u., or 13.4 per cent of the heat from the exhaust steam which had previously been wasted. This would be returned to the boiler as a saving from the feedwater heating.

If the feedwater is discharged from the exhaust-steam heater at more than 225 deg., which implies a back pressure of 10 lb. and is as hot as could normally be expected with that temperature of heating medium, there is still a range of 166 deg. that it can be raised before reaching the temperature corresponding to the boiler pressure. This would then have to be done by the exhaust gases, which have a temperature suitable for the purpose, frequently being 700 deg. or more. This would require, in this instance, the absorption of 5,868,000 B.t.u., or about 51 per cent of the heat contained in the exhaust gases.

There are no reliable figures available in regard to the transfer of heat from front-end gases of a locomotive to water on a unit basis, but it is quite probable that with any practical form of apparatus a heat transfer greater than 15 B.t.u. per sq. ft. per hour. per deg. average temperature difference will not be exceeded. If we accept this figure for the purposes of investigation and assume that there will be an average temperature difference between the hot gases and the water of 250 deg., it develops that over 1500 sq. ft. of heating surface will be required to raise the water 163 deg. in temperature. It is evident, therefore, that a form of construction which will give a higher heat transfer per square foot than that assumed will have to be developed and perfected, or it will be necessary to be satisfied with the lower temperature of feedwater.

Another feature of the subject which should not be overlooked is the effect of feedwater heating on the boiler efficiency. As the rate of combustion is decreased, the boiler efficiency increases, and when a feedwater heater is applied to the locomotive it allows the production of the desired amount of steam with a reduction in the amount of coal fired, which increases the boiler efficiency, in turn requiring still less coal to produce the results desired. In this way a very material saving is accomplished in the whole locomotive, which, while not produced by the feedwater heater, results from its application. In the case of a large passenger locomotive a reduction of 10 lb. of coal per sq. ft. of grate area per hour gives an increase in the boiler efficiency of about 3 per cent, which should be credited to the heater.

In order that the maximum amount of heat may be absorbed from the exhaust steam, it is necessary that the water shall enter the heater at the lowest possible temperature, which requires the use of a pump to force the water through the heater in the case of a closed heater similar to the one illustrated, or draw it from the heater in the case of an open type of heater. In the case of the open type of heater, temperatures greater than 212 deg. will not be obtainable, and this fact, in addition to the well-known difficulties that accompany the practice of pumping hot water, make it advisable to place the pump between the water supply and the heater and use the closed-type or pressure heater.

A satisfactory pump for this purpose should not only be reliable, durable and suitable for operating under the highly difficult conditions present on a moving locomotive, and also require an absolute minimum of attention for its maintenance, but it must also give a very high efficiency since the steam it requires for operation is practically a net loss to the locomotive as a whole. It is of course good practice to discharge the exhaust from the feed pump into the heater and there condense it, but the amount of heat taken up from this source reduces the amount that can be absorbed by the feedwater from the exhaust steam of the cylinders, and therefore, so far as economy is concerned, it gives no advantage.

A pump has recently been perfected by the Westinghouse Air Brake Company for use on locomotives which appears to answer the requirements in a very satisfactory manner. It is able to deliver more than 50 lb. of water against a pressure of 240 lb. for each pound of steam, at 150 lb. pressure, and will handle about 65,000 lb. of water per hour as a maximum. The amount of water pumped is controlled by the steam pressure on the pump through the medium of a simple throttle valve located in the cab and operated by the engineer.

A rule of thumb that has long been used in stationary and marine practice is that for each 11 degrees the feedwater is heated by a source otherwise wasted, there will be 1 per cent saving in fuel. Such experiments as have been made on locomotives indicate that this amount is conservative and can be easily attained. When the maximum capacity of the locomotive is being used, savings considerably in excess of this are indicated. It appears that an economy of at least 10 per cent can be reasonably expected even at light rates of working.

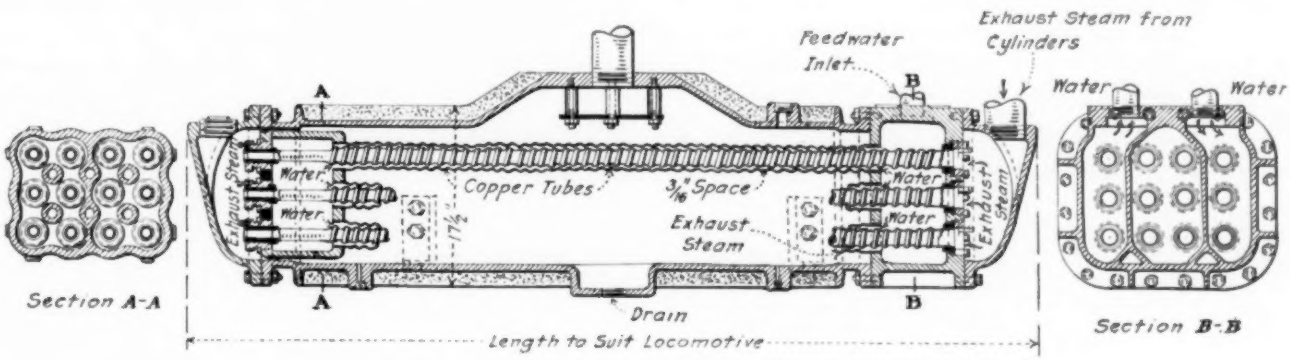

Fig. 1 Locomotive Feedwater Heater Shown in Section

THE LOCOMOTIVE FIREBOX AND COMBUSTION CHAMBER

By J. T. ANTHONY,[1] NEW YORK, N. Y.

THE growing demands and economic problems confronting the railroads have resulted, among other things, in increased train loads. This has necessitated a large increase in the capacity of motive-power units required, which has been obtained by increasing the size of the locomotive and the steaming capacity of its boiler. Since the sustained hauling capacity of a locomotive depends upon the ability of its boiler to deliver steam, and the steam generation depends upon the amount of coal that can be burned and heat liberated, the firebox has been the controlling factor in the successful operation of high-capacity locomotives.

The operating conditions of the future are problematical, but the indications are that in addition to present demands

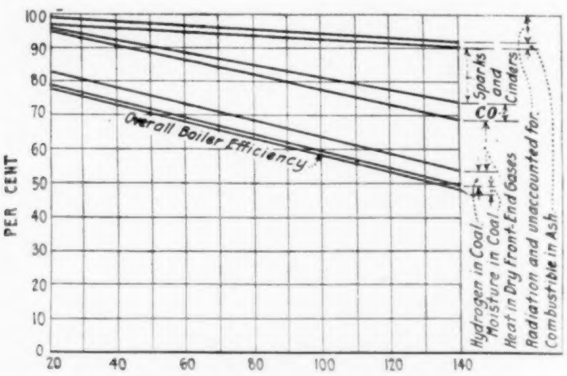

FIG. 1 HEAT LOSS AND BOILER EFFICIENCY AS AFFECTED BY RATE OF COMBUSTION

for high hauling capacity there will be a demand for higher speeds. The average locomotive is in service doing useful work 4 hr. and 17 min. out of each 24 hr., with a daily average of about 75 miles. It is highly probable that strenuous efforts will be made in the future to increase the amount of time the locomotive is engaged in useful work, and to increase the length of the runs and locomotive mileage per day by changing crews when necessary.

If these conditions arise, the controlling factor will be the firebox and its ability to burn the coal properly and liberate the heat required over long periods of time. Regarded from the standpoint of present operating conditions or possible future conditions, the locomotive firebox is a vital factor; and no operating or mechanical official can afford to neglect the study of its present defects or future possibilities.

The firebox has two functions to perform. The first and most important is the burning of the coal and liberation of the heat contained. The second is the absorption of heat by the firebox heating surfaces.

Only a part of the coal burns on the grates. Under normal conditions at least 50 per cent of the heat is liberated by the burning of gases above the fuel bed. Ample air supply, thorough mixing of the gases, and combustion space are necessary for the complete burning of the gases. For efficient firebox performance, combustion chambers and mixing devices are as necessary as the grates.

The firebox furnishes only 5 to 10 per cent of the total heating surface, but is responsible for 25 to 50 per cent of the total evaporation, due to the fact that its heating surfaces are ideally disposed for the absorption of radiant heat. Maximum boiler capacity and efficiency cannot be obtained without providing for the generation and absorption of this radiant heat.

Fig. 1 shows a fair average of boiler efficiency and heat losses on modern locomotives equipped with brick arches and superheaters. It will be noted that the boiler efficiency drops from about 78 per cent down to 48 per cent as the rate of combustion increases from 20 to 140 lb. of coal per sq. ft. of grate per hour. It will also be noted that the greatest heat losses are those due to the heat carried away by the front-end gases and the heat loss in sparks and cinders; the former remaining nearly uniform throughout the range of tests, while the latter increases rapidly as the rate of combustion increases.

It is common practice to design locomotives to deliver their rated tractive effort when burning 120 lb. of coal per sq. ft. of grate per hour. Fig. 2 shows the average heat distribution and losses at this rate of combustion. Fifty-three per cent of the heat contained in the coal is absorbed by the boiler and 47 per cent lost. Of the heat lost, 27 per cent is chargeable to the furnace, 6 per cent to the heating surfaces, and 14 per cent is unavoidably lost in the front-end gases.

A comparison of *D* and *I* in Fig. 2 indicates clearly that the furnace (or firebox) is responsible for four times as much heat

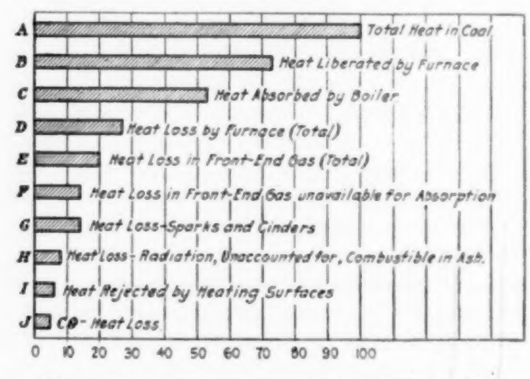

FIG. 2 HEAT DISTRIBUTION AND LOSSES WHEN FIRING COAL AT THE RATE OF 120 LB. PER HOUR PER SQ. FT. OF GRATE

waste as the boiler heating surfaces; and it becomes very evident that the largest field for improvement lies in the locomotive firebox, and not in the heat-absorbing surfaces. This is an all-important fact and one that should be borne in mind: that it profits us little to provide large areas of heating surfaces if proper provisions for burning the coal are not made in the firebox.

FIREBOX LOSSES

Firebox losses consist of:

1 *Combustible in Ash,* due partly to character of coal and to grate design and method of firing. Loss of this nature

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is generally small, not amounting to more than 1 to $1\frac{1}{2}$ per cent.

2 *Carbon Monoxide.* This gas is unavoidably formed in large quantities in the fuel bed, and must be burned in the combustion-chamber space. Its formation can be reduced by providing grate area sufficient to prevent high rates of combustion and to allow a light fire to be carried, thereby insuring an ample air supply, both in the fuel bed and in the firebox space above. Once formed, the gas can be completely burned only by *mixing* with an excess of oxygen and providing ample combustion-chamber space.

3 *Unburned Hydrocarbons,* which account for a large part of the so-called "unaccounted-for" losses. These gases are distilled off from the green coal and burn above the fuel bed. To burn them completely it is necessary to provide an excess of oxygen above the fuel bed, to mix thoroughly, and to have a large combustion chamber and long flameway. Even with these provisions it is very difficult to burn some of the heavy hydrocarbons, which are driven off in the form of tarry vapors.

4 *Sparks and Cinders* are responsible for the largest heat loss at high rates of combustion. This loss can be greatly reduced by increasing the grate area and reducing the velocity of the draft through the fuel bed. Refractory baffles to break up and deflect the cinders, and combustion chambers of ample volume and length wherein the fine particles can burn, will cause a further reduction in these losses.

Summed up, the elimination or reduction of the firebox losses can be brought about by increasing the grate area, fire-

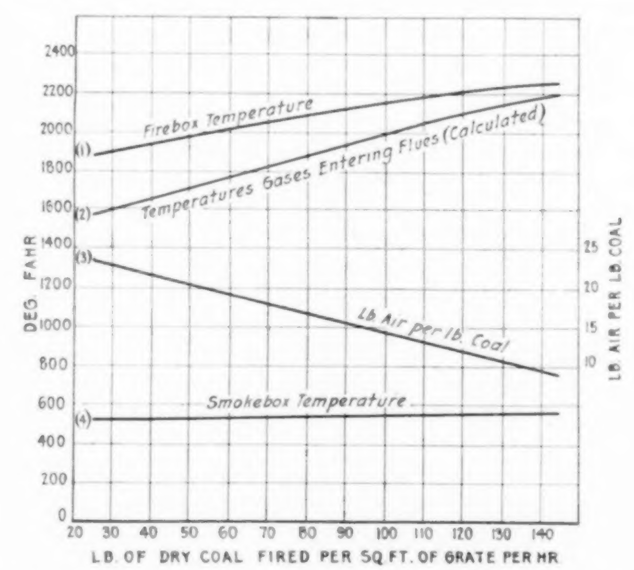

FIG. 3 CHART SHOWING EFFECT OF RATE OF COMBUSTION ON FIREBOX AND SMOKEBOX TEMPERATURES, TEMPERATURE OF GASES ENTERING FLUES, AND AIR SUPPLY PER POUND OF COAL

box volume and combustion-chamber space by providing effectual baffles and mixing devices, and supplying at least 33 per cent excess air, or approximately 16 lb. of air per lb. of coal.

Air sufficient for complete combustion can be drawn into the firebox at low and moderate rates of combustion if sufficient openings are provided in ashpans and grates. At high rates of combustion it is impossible to get enough air into the firebox to complete combustion, and this is always found to be the controlling factor when driving locomotives to their maximum capacity.

COMBUSTION CHAMBERS

Ordinarily, we are apt to think of coal as burning on the grates, when as a matter of fact a large part of the coal burns above the fuel bed in the form of gas. Consider the case of the large boiler, such as is used on the Pacific- and Mikado-type engines, with 70 sq. ft. of grate, 311 cu. ft. of firebox volume, 232 sq. ft. of firebox heating surface and 5280 sq. ft. of flue and superheating surface, the firebox being without a

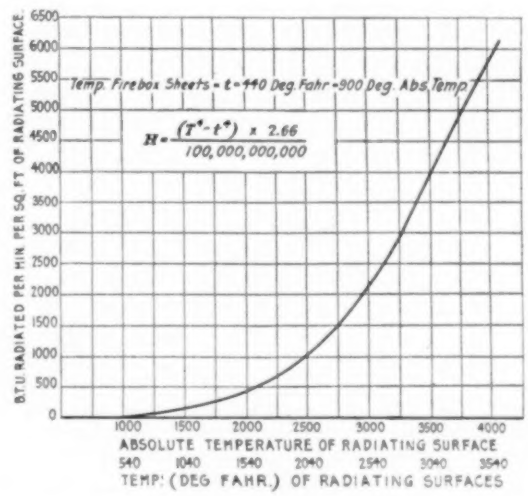

FIG. 4 AMOUNT OF HEAT RADIATED PER MINUTE PER SQUARE FOOT OF RADIATING SURFACE WHEN TEMPERATURE OF FIRE SIDE OF FIREBOX SHEETS IS 440 DEG. FAHR.

combustion chamber and equipped with a brick arch. The coal used was high-volatile Westmoreland with a heat value of 14,430 B.t.u. per lb. and having the following composition:

	Per cent		Per cent
Fixed carbon	57	Carbon	78
Volatile matter	35	Hydrogen	$5\frac{3}{4}$
Moisture	1	Nitrogen	$1\frac{1}{2}$
Ash	7	Sulphur	$1\frac{1}{2}$
	—	Ash	7
	100	Oxygen	$6\frac{1}{4}$
			—
			100

At a rate of combustion of 120 lb. of coal per square ft. of grate per hour, 8400 lb. was fired (which is equivalent to 140 lb. per min., or 2.33 lb. per sec.). The coal contained 57 per cent of fixed carbon; and if all this burned on the grate, there would be liberated 8350 heat units—or 58 per cent of the heat contained in the coal—while 6080 heat units (or 42 per cent) would be liberated by the volatile combustible burning above the fuel bed.

However, all of the fixed carbon does not burn on the grate. The oxygen, on coming in contact with the glowing coals next to the grate, combines with the carbon to form carbon dioxide, and this, passing up through the fuel bed, comes in contact with other glowing coals and is reduced to carbon monoxide; and there is a large percentage of the latter gas mixed with the carbon dioxide and other gases arising from the fuel bed.

Tests indicate that often there is as much as 80 per cent of the fixed carbon incompletely burned to carbon monoxide,

and in order to avoid a large heat loss, this carbon monoxide must be mixed with sufficient oxygen to enable it to be completely burned in the combustion-chamber space above the fuel bed.

Assume, for example, that 50 per cent of the fixed carbon is completely burned on the grates and 50 per cent is incompletely burned to carbon monoxide. The gases arising from the fuel bed will have the composition, weight and volume shown in Table 1.

TABLE 1 COMPOSITION AND VOLUME OF GASES IN FIREBOX

WHEN BURNING 120 LB. OF COAL PER SQUARE FOOT OF GRATE PER HOUR, WITH AN AIR SUPPLY OF 12¼ LB., AND ONE-HALF OF FIXED CARBON COMPLETELY BURNED ON THE GRATES. FIREBOX TEMPERATURE = 2200 DEG. FAHR.

Gas	Symbol	Arising from Fuel Bed			Combustion Completed	
		Lb. per Sec.	Cu. Ft. per Sec.	Per Cent Vol.	Cu. Ft. per Sec.	Per Cent Vol.
Ethane[1]	C_2H_6	0.50	38	1.87	0	0
Carbon monoxide	CO	1.55	107	5.27	0	0
Carbon dioxide	CO_2	2.44	107	5.27	290	14.53
Nitrogen	N_2	21.96	1517	74.73	1517	76.06
Oxygen	O_2	3.99	242	11.92	55	2.75
Water vapor	H_2O	0.16	17	0.84	131	6.56
Sulphur dioxide	SO_2	0.07	2	0.10	2	0.10
Totals	....	30.67	2030	100.00	1995	100.00

[1] Ethane assumed to represent average composition of the hydrocarbons.

Under these conditions, only 40 per cent of the heat contained in the coal would be liberated on the grate, while 60 per cent would be liberated by the burning of the gases in the combustion-chamber space.

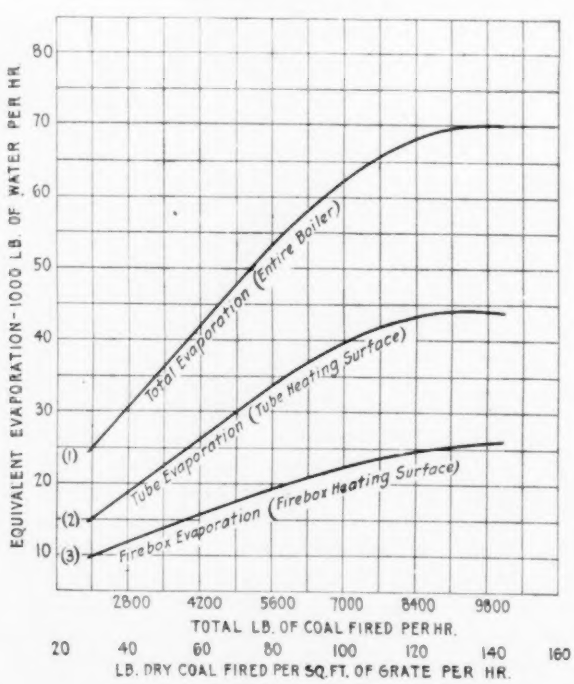

FIG 5 EQUIVALENT EVAPORATION PER HOUR FOR VARIOUS RATES OF FIRING

We have assumed that the combustion in the firebox is complete and that there is no hydrocarbon or carbon monoxide contained in the gases entering the flues, as shown by the right-hand column of the table. Under the conditions, however, perfect combustion could not be obtained, as the air supply, 12¼ lb. per pound of coal, is insufficient. Table 1 shows that there is an excess of 2.75 per cent free oxygen in the final products of combustion; but this is not sufficient to guarantee complete combustion, on account of the presence of the large volumes of inert gases, which interfere with the mixing of the oxygen with the combustibles; and also on account of the short time available for combustion of each particle of gas.

The velocity with which the combustible gases burn depends upon the volume percentages of the combustible and the oxygen present. For instance, with the gases arising from the fuel bed containing 5 per cent carbon monoxide and 12 per cent oxygen, the velocity of combustion would be proportional to $5^2 \times 12 = 300$.

Where combustion is nearly complete and the gases contain, say, 1 per cent carbon monoxide and 3 per cent oxygen, the velocity of combustion would be proportional to $1^2 \times 3 = 3$; or it would be 100 times more rapid in the first than in the second case. This slowness of combustion can be partially offset by providing long flameway and combustion-chamber space; but in addition combustion must be speeded up by increasing the supply of oxygen if perfect combustion is to be obtained.

As shown, the total volume of gases evolved per second is more than 2000 cu. ft. The firebox has a volume of 311 cu. ft., which means that the firebox is being filled and refilled with gases about six and one-half times per second; or that the time available for the combustion of each particle of gas will average less than one-sixth of a second.

It is evident from the above that it is a very difficult matter to burn completely the combustible gases in an ordinary firebox, although, as a rule, front-end-gas analyses fail to account for these losses. This is due to our method of making these analyses, no provision being made ordinarily to detect the presence of unburned hydrocarbons; while the presence of a small percentage of carbon monoxide may often pass undetected, owing to methods employed in collecting gas samples and to chances for error in gas analyses.

The presence of 0.1 per cent of unburned hydrocarbon in the front-end gas under the above conditions would indicate a loss of more than 2 per cent of the entire heat contained in the coal; and such losses, and much larger losses, are constantly occurring.

The large volume of gases evolved and the amount of heat generated by the burning of these gases emphasize the importance of firebox volume and combustion-chamber space. The fuel bed is little more than a gas producer, and adequate provisions must be made for burning these gases if perfect combustion is to be approximated.

FIREBOX HEATING SURFACE

Fig. 3 shows the firebox and smokebox temperatures and air supply per pound of coal, obtained in tests of the locomotive under consideration. It will be noted that as the rate of combustion increased from 30 to 140 lb. of coal, the firebox temperature rose from 1900 to 2240 deg. fahr., while the smokebox temperature increased from 520 to 580 deg. At the same time the air supply per pound of coal decreased from 22½ to 10 lb. The firebox temperature shown is probably higher than that generally obtained in road service; but high

firebox temperatures are much to be desired, as the evaporation increases rapidly with the rise in temperature.

Firebox heating surfaces receive practically all of their heat by radiation, the heat being radiated directly from the luminous fuel bed, flames and brickwork, traveling from these radiating surfaces by "rays" to the firebox heating surfaces.

The locomotive firebox is ideally suited to the absorption of radiant heat, having the radiating bodies, such as the fuel bed and flames, surrounded by the cooler, soot-covered heating surfaces, which absorb all the radiant heat and reflect none of it away.

The curve in Fig. 4 shows the amount of heat radiated per minute per square foot of radiating surface for various firebox temperatures when the temperature of a firebox sheet on the fire side is 440 deg. fahr. The points determining the curve were figured from the formula (Stefan-Boltzmann) shown, absolute temperatures being used. With a firebox temperature of 1540 deg., each square foot of radiating surface gives off about 400 heat units; whereas, if the temperature is increased to 2040 deg., more than 1000 heat units are radiated per minute; while a temperature of 3000 deg. would give a radiation of almost 4000 heat units per minute per square foot of radiating surface.

High firebox temperatures are necessary if high firebox evaporation is to be obtained; but temperature is but one of the two controlling factors, the other being the area or extent of the radiating surfaces. The fuel bed is a radiating body, and the area of the radiating surface of the fuel bed is readily determined. Flames also radiate heat, but the amount of flame in a firebox is very variable and the amount of heat radiated therefrom is difficult to determine. If the firebox is completely filled with a mass of flame, the effective flame-radiating surfaces will be equal to the exposed firebox heating surfaces. If the firebox is not completely filled with flame, the flame-radiating surfaces will be less.

Assuming that the firebox was completely filled with flame when burning the high-volatile coal at a rate of 80 lb. per square foot of grate per hour and was 50 per cent filled at the low rates of combustion, Curve 3 in Fig. 5 was plotted, the flame temperature being assumed to equal that of the firebox. The curve showing the total equivalent evaporation from the boiler was plotted from actual test data. The curve of firebox evaporation was calculated from the curve in Fig. 4, using the firebox temperatures shown in Fig. 3. The curve showing tube evaporation was obtained by subtracting the firebox evaporation from the total.

At the lowest rate of evaporation the curve indicates that the firebox evaporated 40 per cent of the total, and at the highest rate, 37 per cent. An equivalent evaporation of 26,000 lb. per hour from 230 sq. ft. of heating surface means an evaporation of 105.6 lb. per hour per sq. ft. of heating surface. In order to get such an evaporation, each square foot of heating surface would have to transfer 102,400 heat units per hour, and the temperature on the fire side of the sheet would be about 536 deg. if the sheets were clean. These figures will serve to show what can be expected when high firebox temperatures and large radiating surfaces are to be had; for firebox evaporation depends principally upon these two factors, and only indirectly upon the extent of the firebox heating surfaces.

Increasing the firebox heating surfaces by the addition of a combustion chamber increases the firebox evaporation only to the extent that the combustion chamber is filled with flame or heat-radiating surfaces. If the combustion chamber is not filled with flame, there will be practically no increase in firebox evaporation; for the combustion-chamber heating surface is so arranged that it can take up but an inappreciable amount of heat from the gases by convection.

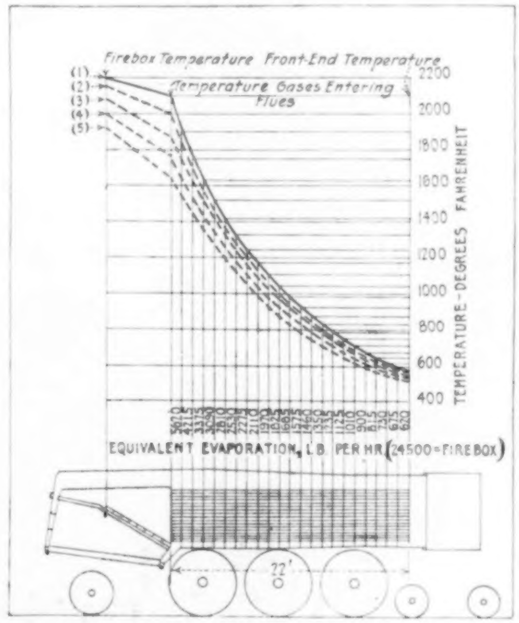

FIG 6. TEMPERATURE DROP FROM FIREBOX TO FRONT END AT VARIOUS RATES OF COMBUSTION

(1), 120 lb. per sq. ft. of grate per hour; (2), 100 lb.; (3), 80 lb.; (4), 60 lb.; (5), 40 lb. Evaporation for each 1-ft. section of tubes calculated from temperature drop shown by Curve (1)

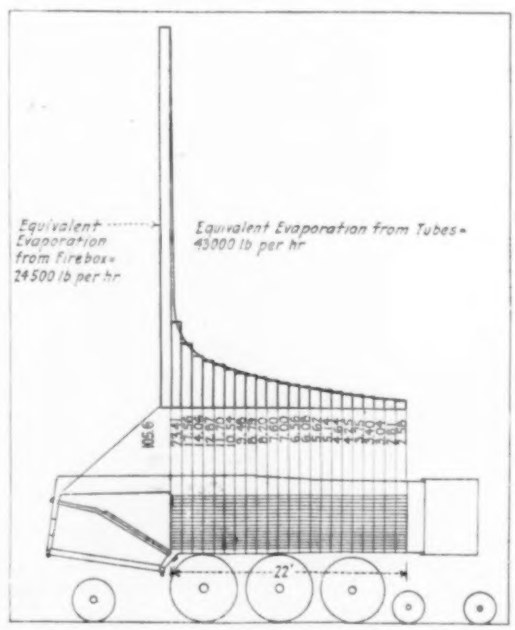

FIG. 7 EQUIVALENT EVAPORATION PER HOUR FROM FIREBOX AND FROM EACH 1-FT. SECTION OF TUBES WHEN BURNING 120 LB. COAL PER SQ. FT. OF GRATE PER HOUR

Figures show equivalent evaporation per sq. ft. of heating surface per hour. Grate area, 70 sq. ft; firebox heating surface, 232 sq. ft.; tube-heating surface, 5280 sq. ft. = 240 sq. ft. per 1-ft. section.

The curves in Fig. 6 show the characteristic drops in temperature of the gases in passing through the flues when burn-

ing coal at varying rates per square foot of grate per hour, with the air supply shown in Fig. 3.

Suppose the flues to have been divided into 22 equal sections, each 1 ft. in length and containing 240 sq. ft. of heating surface. With a constant weight of gases passing through, the drop in temperature through each 1-ft. section becomes a measure of the evaporation in that section; and the figures per square foot of flue heating surface would be 8.14 lb. per hour, this evaporation ranging from 23.4 lb. in the section next to the firebox down to 2.58 lb. per sq. ft. in the section adjacent to the front flue sheet. It will be noted that the first four sections from the front end have a total equivalent evaporation of only 2840 lb. per hour, or about half that produced by the one section adjacent to the back flue sheet.

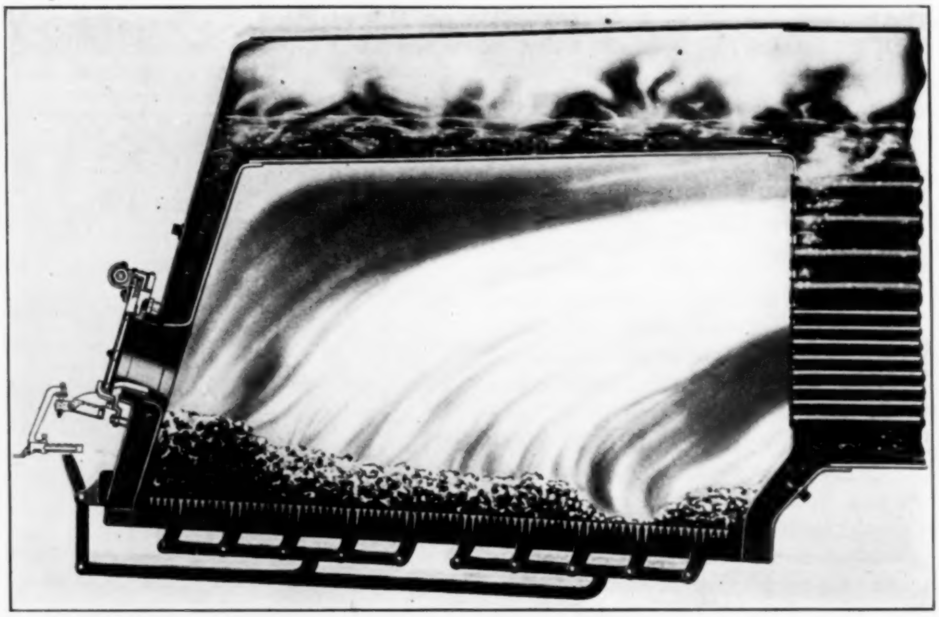

Fig. 8 Ordinary Firebox without Baffle or Other Gas-Mixing Device

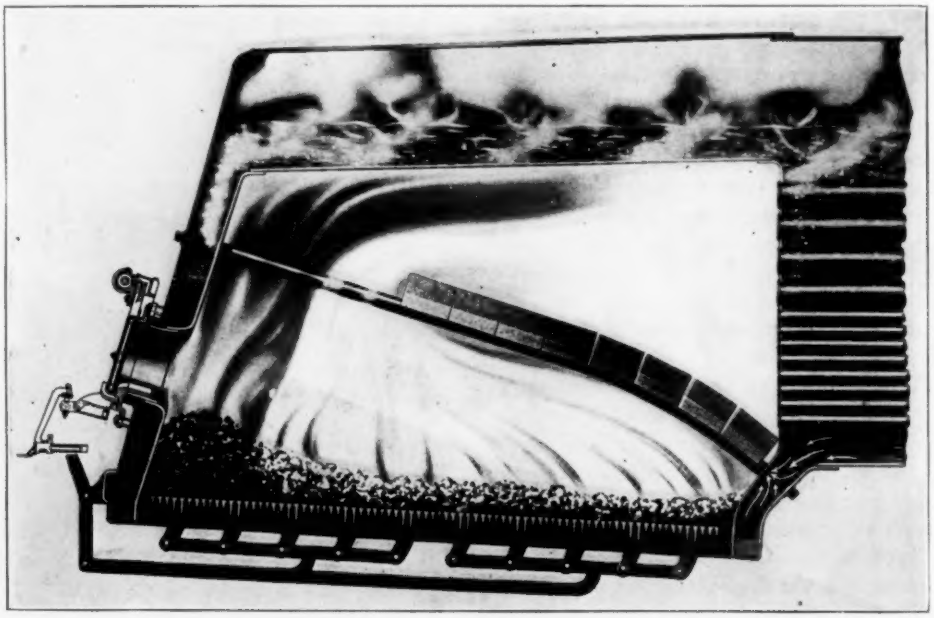

Fig. 9 Ordinary Type of Firebox Equipped with an Arch

showing the total equivalent evaporation from each section and the equivalent evaporation per square foot of heating surface were calculated from the temperature drops and the weight of the gases, assuming the specific heat to be constant throughout. This assumption introduces a small error into the calculations, but it is not sufficient to affect the results greatly.

With an equivalent evaporation per square foot of firebox heating surface of 105.6 lb. per hour, the average evaporation

A reduction of the flue lengths to, say, 18 ft. by the application of a 4-ft. combustion chamber would reduce the flue heating surface 960 sq. ft., increase the firebox surface by 76 sq. ft., and add 108 cu. ft. to the firebox volume. What effect would such a change have upon the boiler evaporation and efficiency?

As shown in Fig. 2, more than 25 per cent of the heat contained in the coal is lost through imperfect combustion. If

the additional firebox volume obtained by the use of the combustion chamber effected a saving of one-fourth of this heat loss, the resulting combustion would cause an increase in firebox evaporation of approximately 8025 lb. to offset the 2840 lb. lost by shortening the flues.

Boiler tests show even larger increases in efficiency brought about by the introduction of the combustion chamber; and a study of the questions of furnace losses and heat generation by the burning gases will make it clear why the application of a combustion chamber to a locomotive does increase fire-

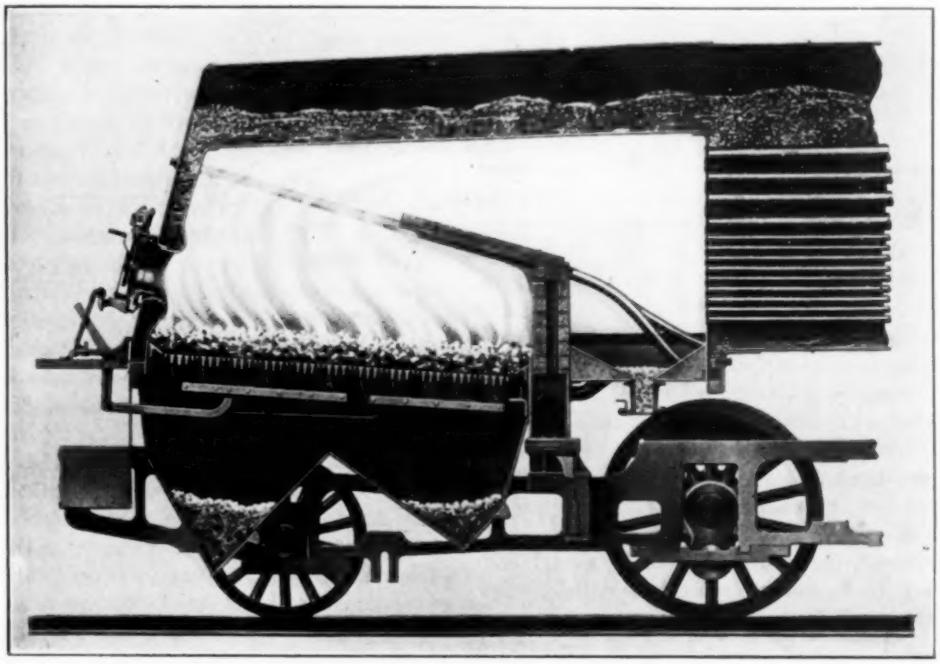

Fig. 10 Firebox Equipped with the Gaines Locomotive Furnace

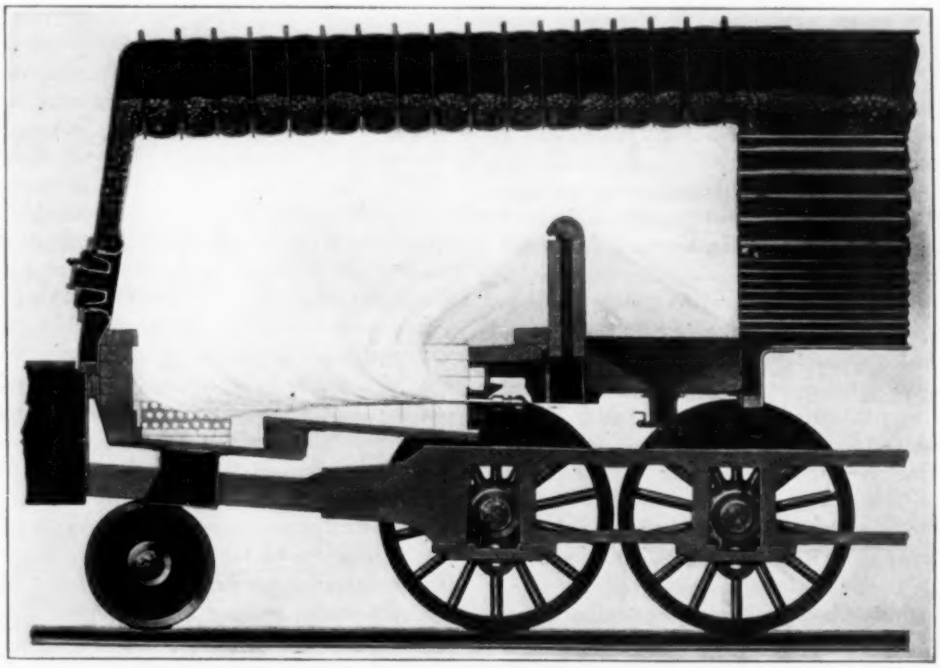

Fig. 11 Straight-Wall Type of Gaines Combustion Chamber as Applied to an Oil-Burning Locomotive of the 2-10-2 Type

This increased firebox evaporation would be obtained by the generation of heat that would otherwise have been lost, and there would be little or no reduction in the temperature of gases entering the flues. The front-end temperature would be increased, but there would be a net increase of 7½ per cent in boiler efficiency, due to the combustion chamber.

box evaporation and decreases the heat losses caused by the escape of unburned volatile combustibles and fine particles of coal.

While comparatively few reliable tests have been made for the purpose of determining the effect of a combustion-chamber installation upon boiler efficiency, the three shown in Table 2

give a clear indication of the value of firebox volume and combustion-chamber space.

TABLE 2

Locomotive Type	Cylinder Size	Fuel Used	Relative Boiler Efficiency, Per Cent.	
			With Gaines Combustion Chamber	Without
2-8-0	21x32 in.	Coal	100	62
4-6-2	23x28 in.	Coal	100	78
2-10-2	28x32 in.	Oil	100	80

The variation in boiler efficiencies in the table is due partly to the character of the fuel and partly to the difference in lengths of combustion chambers and peculiarities of firebox design.

The relative efficiency of the firebox heating surfaces as compared with the flue heating surfaces is shown by the curve in Fig. 7. The base of the rectangle represents the heating surface, 240 sq. ft. for each section of the flues and 232 sq. ft. for the firebox. The height of the rectangle indicates equivalent evaporation per square foot of heating surface per hour from each of the flue sections, while the area of each rectangle represents the total evaporation per hour.

The principal function of the firebox is to burn coal and liberate the heat; but the amount of water evaporated by the firebox heating surfaces, as shown by the chart, is quite considerable, and full advantage should be taken of the opportunities offered for producing and absorbing radiant heat. Whether considered as a furnace or as a part of the boiler evaporating surface, the firebox is the chief factor in successful boiler performance, on which depends successful locomotive operation.

The value of baffling and gas-mixing devices, firebox volume and combustion-chamber space is becoming more generally recognized, although the engines with long wheelbases and boilers now in vogue present opportunities for combustion-chamber installations of which full advantage is not being taken by many of the American railroads. The advance that has been made along these lines during the past few years is shown by the following illustrations.

Fig. 8 shows the ordinary firebox without a baffle or gas-mixing device of any description. The picture shows clearly the disadvantages of such a firebox and the possibilities of large heat losses due to the escape of unburned hydrocarbon gases distilled off from the bank of green coal under the door, and to the heat loss and flue trouble occasioned by the inrush of cold air through a possible hole in the fire.

Fig. 9 shows the same type of firebox equipped with an arch, and illustrates the advantages of the baffling and mixing obtained by the arch, as well as the protection afforded the flues.

Fig. 10 shows a firebox equipped with the Gaines locomotive furnace, in which the flue sheet is carried forward to a point directly over the rear driver, the mudrings being upset at the sides to provide sufficient clearance.

Fig. 11 shows a straight-wall type of Gaines combustion chamber, as applied to an oil-burning locomotive of the 2-10-2 type. This is the first installation of its kind that has been made on road engines.

These latter illustrations show the furnace layouts of locomotives that are in actual operation; and the results obtained in fuel economy, boiler capacity and low cost of maintenance give additional weight to the arguments advanced regarding the effect of heat radiation from fuel bed, flameways and brickwork, and the necessity of large firebox volume and long flameway.

Rhotanium—A Platinum Substitute

Rhotanium, a palladium-gold alloy in which the gold content varies from 60 to 90 per cent, is said to form a satisfactory substitute for platinum. It is malleable and ductile and can be welded without the use of a flux or other reagent. Its specific gravity ranges from about 16 to 18.5, according to composition, and its losses by volatilization at temperatures below 1300 deg. cent. are less than those of commercial platinum. It can be used, within its temperature limitations, in electric heating units, and is satisfactory for contact terminals in many forms of automatic electric devices. Its behavior when tested on certain magnetos was satisfactory, but experiments performed on a high-grade aeroplane-engine magneto gave negative results. It is not suitable for use with hot concentrated nitric acid nor for electrolytic anodes, but for all other chemical purposes it is entirely satisfactory if the proper composition is chosen and if properly manufactured. Certain of the alloys have given good service in dentistry when used for pins and baked into porcelain teeth and as thin foil and heavy sheet for other types of construction. Rhotanium is said to be superior to pure platinum for use in jewelry; it is harder, stronger, and takes a better finish. It does not tarnish, is non-corrodible, has practically the color of platinum, and can be worked as readily. Jewelry made with it passes the common jewelers' and platinum buyers' tests. (U. S. Commerce Reports, abstracted in *Machinery*, vol. 23, no. 12, August 1917, p. 1096)

Patent Merger in Aircraft

According to statements in the press, the manufacturers of aircraft have formed an organization under the name of Manufacturers' Aircraft Association. The most important feature of this association is an agreement entered into by the manufacturers composing it, with a view to cross-licensing the various patents held by the members.

According to a statement given out by the chairman of the publicity committee of the association, it is proposed that each member should pay a royalty of $200 on each machine built by him. Of this sum $135 will be paid to the Wright interests and $40 to the Curtiss interests until the Wright interests have accumulated $2,000,000. Thereafter $175 will go to the Curtiss interests until they have accumulated a similar sum. The residue of $25 on each machine is to go to the general fund of the association.

By the terms of the cross-licensing agreement any responsible manufacturer of aircraft, or one who intends to become a bona-fide producer of same, or any manufacturer to whom the United States Government has given a contract for the construction of ten or more aeroplanes, or any person, firm, or corporation owning or controlling United States patents relating to aeroplanes, may become a party to the agreement and can qualify as a member.

Under the terms of this agreement all patent litigation relating to aeroplanes between members of the association ceases automatically. From the text of the announcement and statements made by the officers, it appears that the agreement covers the aeroplane proper, but not the engine.

The office of the association is at 501 Fifth Ave., New York City. Frank H. Russell, of the Burgess Company, is president of the association, and Benjamin S. Foss, of the Sturtevant Aeroplane Company, is secretary.

THE POPPET-VALVE STEAM ENGINE

With Special Reference to the Present Status of the Poppet-Valve Uniflow, Semi-Uniflow and Return-Flow Steam Engine in the United States

By SIEGFRIED ROSENZWEIG, NEW YORK, N. Y.

Member of the Society

IT was in the sixties of the last century that the first poppet-valve engine appeared on the market. It was designed by a young Englishman, Charles Brown, chief engineer of the famous firm of Sulzer Bros., of Winterthur, Switzerland.

This first Sulzer engine became, and still is, the standard design of modern poppet-valve engines. The engine has the side shaft driven from the main shaft by a pair of bevel gears; the two admission valves are mounted on the top, and the two exhaust valves placed at the bottom of the cylinder; and mounted on the side shaft are the four eccentrics, straps and rods for the operation of the valve mechanism. The whole arrangement is excellent and possesses many fine points, the consequence of thoughtful and careful design and workmanship.

While the Corliss engine was finding great favor in this country, and also in England and France, engineers in Germany, Austria and Switzerland pinned their faith to the poppet-valve engine, being convinced that, with the advent of higher steam pressures and higher steam temperatures in general, the poppet valve was more suitable for steam distribution than any other kind of valve. Present-day practice demonstrates that these engineers displayed sound judgment.

It is hardly necessary to enter into the subject of high steam pressures and superheat, but a few figures might be of interest. By increasing the steam pressure, the capacity of the engine is correspondingly increased while the additional heat expenditure is very small. For instance, steam at 100 lb. gage contains 1191 B.t.u. per lb.; at 200 lb. 9 B.t.u. more, and at 500 lb. 19 B.t.u. more, showing that the additional heat required for raising the steam pressure is insignificant.

In this respect the following statement may be quoted from a paper read by Robert Cramer on Higher Steam Pressures[1]: "It is apparent that high steam pressures will permit neither slide nor Corliss valves. The advent of higher pressure will cause the poppet valve to come into its own in America, where it is now seldom used, in spite of the great success it has had in Europe for many years, lately the flexible-seat type especially."

The advantages of the poppet valve are:

1 No rubbing surfaces, hence no lubrication, and its adaptability for high temperatures
2 Small weight and practical balance, hence its adaptability for high speed and high steam pressure
3 No possible wear, consequently the engine economy maintained for an indefinite period.

The comparison shown in Fig. 1 is taken from actual designs. The two valves have the same free area, 65 sq. in., while the weight of the four poppet valves is 72 lb. as against 824 lb. for the four Corliss valves.

Presented at a meeting of the New York Section of The American Society of Mechanical Engineers., May 8, 1917.

[1] Trans. Am. Soc. M.E., vol. 37, p. 597.

In order to combine the advantages and disadvantages of simple and compound engines, the idea of passing the steam through the cylinder in a unidirectional flow, known for more than thirty years, was revived and successfully carried out in practice. Professor Stumpf, of Berlin, Germany, deserves the credit of having designed the first modern and practical uniflow engine.

In these engines the steam enters through admission valves at one end of the cylinder, follows the piston during the expansion period, and escapes through exhaust ports arranged in the center of the cylinder and controlled by the piston.

The steam has a tendency to travel always in the same direction in a unidirectional flow engine, as the rarefication of the steam in the cylinder will take place in a direction toward the central exhaust, cooling the cylinder walls next to the exhaust belt more than those at the other end, and causing a gradual decrease of the temperature of the cylinder walls from the hot cylinder cover to the cool exhaust port, corresponding approximately with the temperature of the expanding steam. The considerable losses caused by the cooling action of the cylinder walls during the admission period, and by reevaporation of steam during the exhaust period in ordinary steam engines, are thus almost entirely avoided.

It seems perfectly feasible that a stratification of the steam, with the wettest particles next to the piston, takes place during the expansion period, but it is doubtful whether, as claimed by Professor Stumpf, it can be maintained during exhaust in view of the rather violent action of the steam in the cylinder when the terminal pressure is suddenly reduced to the back pressure.

While it is true that the cylinder cover remains comparatively unaffected by the flow of steam, it has to be admitted that the piston surface is exposed to the action of the steam. However, on account of the circumferentially arranged exhaust ports, the pressure energy is converted into velocity energy within the exhaust ports to a great extent, without cooling the surface of the piston considerably.

When the exhaust port opens, all the moisture accumulated during the expansion period is completely removed and the possibility of water hammer eliminated.

Further advantages of the uniflow cylinder are due to the fact that the clearance surfaces and volume are considerably reduced as exhaust valves of the usual type are eliminated. The exhaust belt provides an exhaust area considerably in excess of that found in ordinary engines, thus making impossible the pressure difference so often encountered between cylinder and exhaust pipe.

Steam leakage through the exhaust port is rendered practically impossible, as the long piston separates it from the admission valves when the steam pressure is high.

It is evident that the unidirectional flow of steam reduces considerably one of the greatest losses encountered in the ordinary or return-flow engine, namely, the cooling of clearance surfaces, and hence initial condensation. The transformation of energy into power can be effected very economically in

one cylinder without the necessity of employing compound and triple-expansion engines as heretofore.

The advantages of the uniflow engines are:

1 Steam enters at one cylinder end and exhausts at the other end, leaving the hot end hot and the cold end cold, and avoiding clearance losses
2 The exhaust valves with their large clearance surfaces and volumes are eliminated
3 Large central exhaust ports are provided which are of about three times the area of those in standard engines

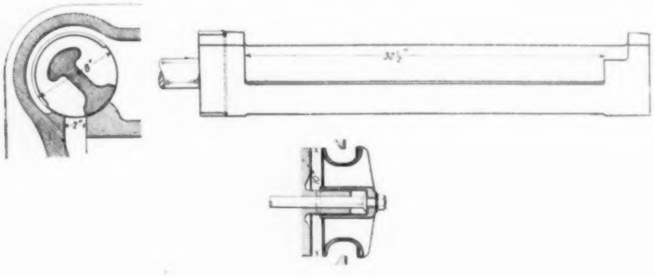

FIG 1 COMPARISON OF CORLISS AND POPPET VALVES

Free area of Corliss valve	65 sq. in.
Weight of four valves	824 lb.
Free area of Poppet valve	65 sq. in.
Weight of four valves	72 lb.

4 Leakage past exhaust valves and piston is eliminated
5 Flat steam-consumption curves are obtained for all loads above and below normal.

Comparative steam consumptions of Corliss, poppet-valve and uniflow poppet-valve engines are given in Fig. 2. Noteworthy is the good economy of poppet-valve engines, especially of the uniflow type, at the smaller loads.

An interesting comparison is afforded by the guaranteed steam consumptions of small turbines and uniflow engines for the new three-million-dollar pumping station of the city of Cleveland, Ohio, showing distinctly the great superiority of uniflow engines over turbines, running condensing and non-condensing.

The equipment consisted of an engine driving a 100-kw. generator at 80 per cent power factor. The steam conditions specified were: 200 lb. gage, 100 deg. fahr. superheat, 2 lb. gage back pressure, when running non-condensing, and a vacuum of 26 in. for the engine, 28 in. for the turbine, when operating condensing.

L. A. Quayle, Mechanical Engineer of the Cleveland Water Department, describing the performance of these engines in *Power,* June 6, 1916, says:

The prices and economy guarantees received on bids from two engine and three turbine builders, as well as informal bids received from two other companies, one a turbine and the other one an engine builder, have been used in making the comparison given here. The prices and guarantee curves represent only the average of three makes of engines and four makes of turbines, including three different makes of generators, all of the bidders being well known.

It is felt that the economy guarantees are conservative, as there was a penalty of $7 per pound of steam per kw-hr. for failure to meet the guaranteed economy, and no bonus was offered for exceeding the guarantees.

STATIONARY ENGINES

Careful experiments carried out by the best authorities during the last few years, on compound and single-cylinder engines of the return-flow and uniflow type, have clearly indicated to the designers of steam engines the principles to be observed in order to obtain highest economies with the simplest mechanical means.

It is essential that, for the sake of economy, clearance in volume and surface be reduced to the lowest possible minimum. In order to obtain the desired results, designers have not hesitated to adopt complicated cylinder and valve-cage designs. Simplicity and accessibility of cylinder and valve-gear parts were sacrificed to economy. A description of the different types of engines will show how an excellent cylinder design can be obtained while employing simple and mechanical means.

The question of valve gear to be used is also of great importance. Complicated mechanisms and trip gears are undesirable, as with them quiet and reliable operation without undue wear is impossible at high speeds. The modern type of steam engine with its steadily increasing rotative speed demands a valve gear of absolutely positive and noiseless operation.

Trip gears are particularly undesirable with poppet-valve engines, as the valve is brought to a sudden stop by coming in contact with the valve seats; such a gear should therefore not be used on engines operating above 100 revolutions.

In order to overcome the disadvantages of the trip valve gears, designs were adopted by means of which the valve was guided back to its seat without being released, avoiding the sudden impact between the metallic surfaces. These so-called positive valve gears were mostly of rather complicated nature and hence were not applicable to high rotative speeds.

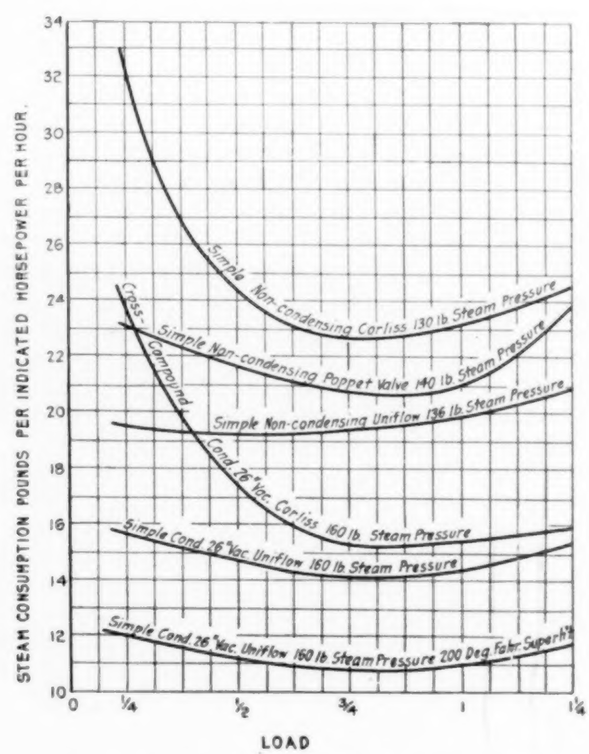

FIG. 2 COMPARISON OF ENGINE PERFORMANCES

The designs of Lentz which were introduced in 1900 and which in this country are manufactured by the Erie City Iron Works, of Erie, Pa., made possible the modern development of the poppet-valve engine. Cam motions such as employed first by Lentz were considered unsafe, as it was feared that the line contact which exists between roller and cam would produce excessive pressures and cause wear on the cam.

The practically universal adaptation of the cam motion for valve gears shows that no wear occurs when the valve-gear working parts are properly designed, made of steel and case-hardened.

Fig. 3 shows the valve gear as used on engines made from the author's designs and as built by the York Mfg. Co., of York, Pa.

In practically 90 per cent of the valve gears for poppet-valve engines, the closing of the valve is partly effected by means of a spring, which is of such strength as to produce not only the retardation forces during the opening but also the acceleration forces necessary during the closing period to keep roller and cam in contact.

A few designers have adopted a double-cam construction, one cam for opening and one for closing the valve, and the spring can thus be omitted. As not only the opening but also the closing is always positively effected by the external valve gear, a short and stiff spring has to be interposed between valve spindle and valve proper to avoid breakage in case foreign matter accumulates on the valve seats. Such valve gear is used by the Nordberg Mfg. Co., Milwaukee, Wis., from the designs of Prof. Doerffel.

All the valve gears mentioned are operated by eccentrics mounted on a lay shaft. It is obvious that the eccentrics may be arranged on the main shaft instead and the valves operated by oscillating levers of the type shown, or by reciprocating camshafts. This arrangement, however, is not as recommendable as the lay-shaft drive except on small engines, as the valve gear is affected by the expansion of the cylinder making resetting under operation conditions necessary. The long eccentric rods and their influence on the regulation are features to be avoided if possible, especially when high speeds are employed.

In several cases the regular Corliss valve gear has been used to operate the poppet valves as adopted in the designs of the Frick Co., Waynesboro, Pa., and in those of the Vilter Mfg. Co., of Milwaukee, Wis.

The high-pressure cylinders of the 6000-hp. engines built by The Hooven, Owens, Rentschler Co., of Hamilton, Ohio, and installed at the plant of the Ford Motor Co., of Detroit, are equipped with poppet valves and the regular Hamilton Corliss gear.

As previously mentioned, trip gears are not recommendable for poppet-valve engines operating at speeds exceeding 100 r.p.m.

As the designs of the author for poppet-valve engines of the return-flow and uniflow poppet-valve type are to a certain extent departures from any other engine of similar type, and as most other designs have been repeatedly described in publications, a more complete description of this engine may not be out of place.

The valve gear of the standard poppet-valve engine is operated by a lay shaft running alongside the engine and driven from the main shaft through a drag crank and shaft by means of a pair of spiral gears. See Fig. 3. The drag crank is self-adjustable and prevents unavoidable motion and jars of the main shaft being transferred to the gears, which for this reason run perfectly noiseless, and are not subjected to any undue wear.

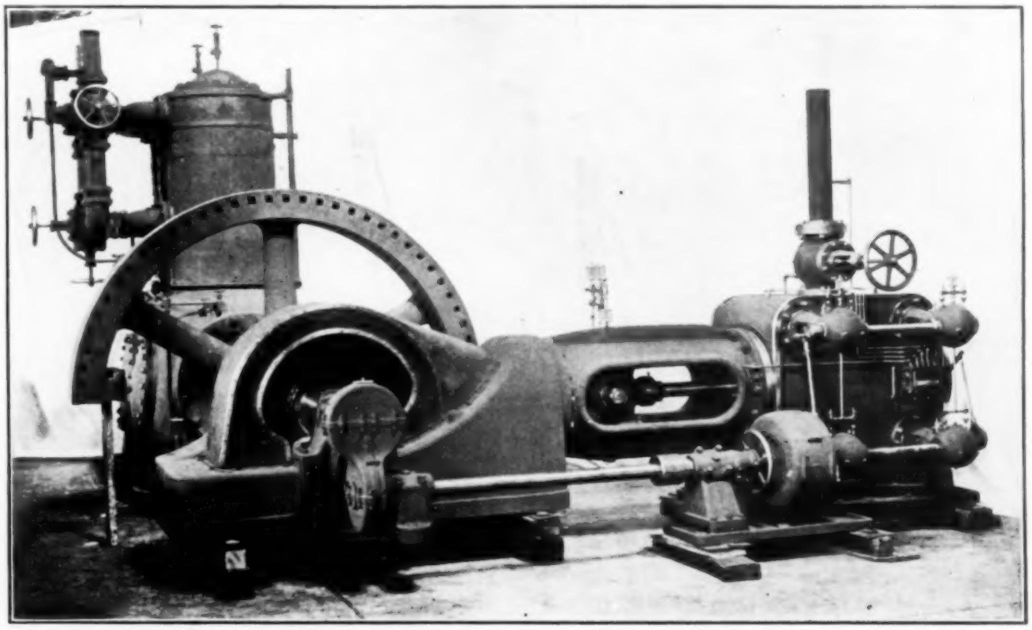

FIG. 3 POPPET-VALVE STEAM ENGINE BUILT BY YORK MANUFACTURING CO.

The lay shaft is placed in line with the exhaust valves, the bonnets of the exhaust-valve gear being provided with bearings to support the shaft. The exhaust valves are operated by cams acting on anti-friction rollers, effecting a rapid opening and closing. The cams are clamped on the shaft and can be shifted into any position to give the desired release and compression.

The arrangement of lay shaft simplifies greatly the exhaust-valve gear, as eccentrics, straps, rods and levers are done away with.

The steam valves, as shown in Fig. 4, are operated by means of oscillating levers provided with rollers and curved cam pieces attached to the valve spindles, insuring, even at the smallest cut-offs, ample and quick valve openings as well as noiseless operation.

The oscillating levers for both valves are mounted on a single shaft which receives its motion from an eccentric rod and eccentric mounted on the lay shaft. It is noteworthy that this arrangement of the valve gear necessitates the use of but

a single eccentric instead of the four eccentrics usually provided in the standard type of poppet-valve engines.

The valves are placed in a horizontal position, well supported by long spindles and guides. The pressure on the valve guide, neglecting spindle guide, amounts to about ½ lb. per square inch. The spindles are lubricated by means of forced lubrication, which passes the oil along the valve spindle through spiral grooves, on to the guide and then into the steam space, thus obtaining a triple effect besides preventing

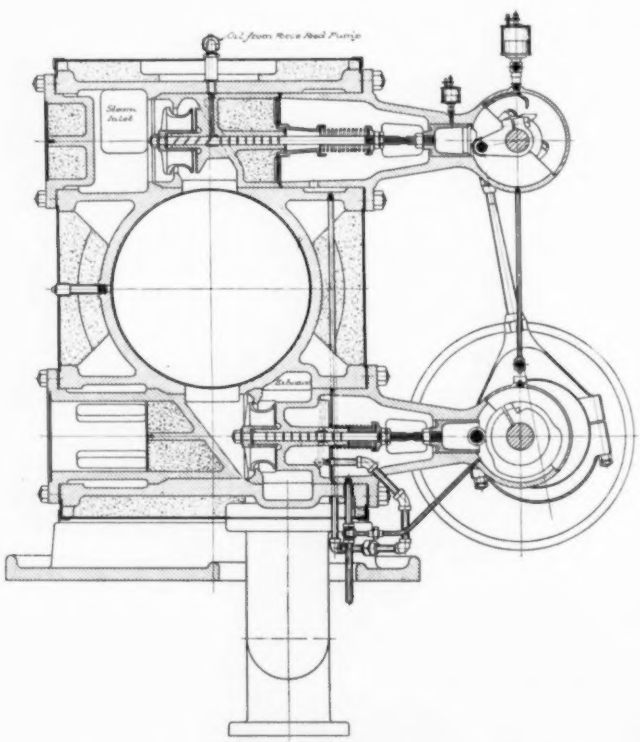

FIG. 4 STEAM VALVES AND VALVE MECHANISM

an escape of steam. The valve spindles are carefully ground into long bushings and provided with labyrinth packings consisting of small circular grooves.

The effective lubrication and the ample support of the valve spindles prevent any bending stresses and preclude the possibility of wear. The horizontal position of the valves and seats is of distinct advantage, as the accumulation of sediment and burnt oil is impossible, the seats being properly cleaned during every steam-admission period.

Of particular interest is the design of the valve cages, which contain not only the valve seats and spindle guides but also the complete structure of the ports. This is a distinct improvement over the usual rib design with its large clearance surface and volume and its unequal expansion. This cage design insures a perfect casting, with a reduction in clearance space not obtained in any other design.

The whole valve assembly is easily accessible by simply removing the back covers without interfering with the valve gear.

The valve-gear parts work in a removable cover, preventing the ingress of dirt, and operate in an oil bath through which the oil may be circulated continuously and used over and over again. Absence of wear and reliability of operation of the valve gear are insured by this arrangement, which is shown in Fig. 5.

A very important part of an engine is the cylinder, and a careful and correct design will prevent great trouble. Early designs, even as late as fifteen years ago, had cylinders in which steam and exhaust chests and cross-overs were cast integral with the cylinder, resulting in a very rigid construction which was not adaptable to high temperatures. As pressures and temperatures continuously increased, it became necessary to separate the two cylinder ends and connect them by means of flexible manifolds. This arrangement allowed a freer and better expansion of the cylinder.

However, it was found advisable also to remove the steam and exhaust chests from that part of the cylinder which was swept by the piston, as under working conditions at high temperatures these stays and ribs caused the cylinder to warp.

In order to meet these conditions, the so-called three-piece cylinder, wherein the valves are placed in a cylinder head and the cylinder proper becomes a barrel with two flanges, came into favor. This design is excellent, mechanically and economically, because it is not subjected to any undue stresses even under high temperatures and pressures, and the steam ports become straight and short, offering small resistance to the steam flow.

However, the cylinder heads constitute difficult, complicated and expensive castings; the erection is awkward and the piston is not very accessible, as steam and exhaust connections have to be broken and valve gears disconnected before the heavy cylinder head can be moved back, usually on slides provided on the extended bedplate.

The author has adapted a one-piece cylinder which it is believed possesses most of the advantages and none of the disadvantages of the three-piece cylinder.

The author's governor arrangement, mounted on a side shaft, is shown in Figs. 5 and 6, for return-flow and uniflow

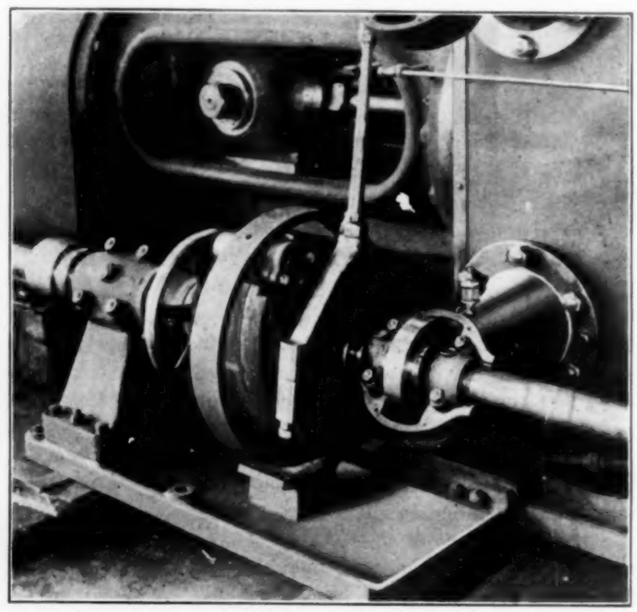

FIG. 5 VALVE GEAR, GOVERNOR AND HAND SPEED ADJUSTMENT

engines respectively. A hand speed adjustment is provided, by means of which it is possible to change the speed while the engine is in operation.

The arrangement of the uniflow engines is generally the same as that of the return-flow engines. The steam valves are operated and regulated in a similar manner as described in previous paragraphs.

A central exhaust port controlled by the piston is provided for the escape of the steam. As this port is of unusually large size—about three times as large as the valves and ports provided in return-flow engines—the release and exhaust of steam takes place very rapidly, and the pressure maintained within the cylinder will be as low as that in the exhaust pipe or condenser. This is a strong point in favor of uniflow engines, as high vacua can be utilized to fullest advantage.

As in the standard type of uniflow engine compression takes place during approximately 90 per cent of the stroke, provision has to be made to overcome excessive compression in case the engine is operated at such back pressures as to cause the final compression pressure to exceed the steam pressure.

The simplest method of decreasing the compression pressure, as used by most designers, is to increase the clearance volume.

After the main exhaust port is closed by the piston, steam is allowed to pass through the auxiliary exhaust valves into the exhaust pipe. The steam travels at a low velocity and is free of moisture, being relieved of pressure and water when the main exhaust port opens, and hence will have practically no cooling effect on the cylinder cover and walls.

The engine built by the Skinner Engine Co., of Erie, Pa., uses auxiliary exhaust valves, placed about 30 per cent of the stroke from the cylinder head, compression commencing as the piston covers up the auxiliary ports.

Several designs of a semi-uniflow type, one of them patented by the author, place the main exhaust valve in the center of the engine. An advantage of this type is that compression is reduced to about 50 per cent, while the clearance of the exhaust valve comes only into action when the steam pressure

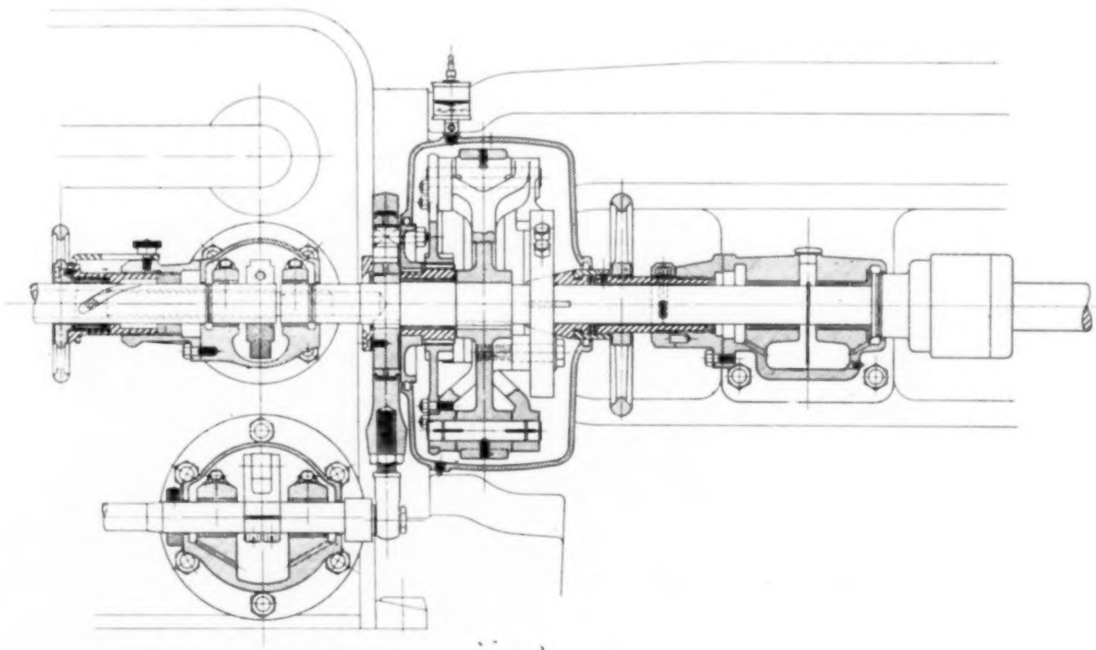

FIG. 6 SECTION OF VALVE CAMS, GOVERNOR AND HAND SPEED ADJUSTMENT

An additional clearance chamber is provided, separated from the cylinder usually by means of a single-seated valve. This valve is operated either by hand or automatically, and the additional clearance chamber connected with the cylinder whenever required by the operating conditions. Such designs have been adopted by the Ames Iron Works, Oswego, N. Y., the Mesta Machine Co., Pittsburgh, Pa., and by most other builders of uniflow engines, being the simplest and easiest way of overcoming the excessive compression.

From an economical point of view, however, this added large clearance surface in particular is very detrimental, and such an arrangement is only permissible when in use temporarily. In case the engine has to operate continuously non-condensing, as, for instance, a locomotive, a concave piston is used which provides the necessary clearance volume, about 16 to 20 per cent of the cylinder volume, with only a slight increase in clearance surface. The added volume is wasteful, and especially so as the cut-offs increase.

In order to reduce the duration of compressión, the original builder of uniflow engines, the Englishman Todd, conceived the idea as far back as the eighties of the last century to provide mechanically operated auxiliary exhaust valves, held open during a fixed period.

is low, and hence its detrimental effect is considerably reduced.

While a high compression is advisable and economical in uniflow engines, as amply demonstrated in many tests, it has also been shown that for practically all working conditions 90 per cent compression is excessive.

Stumpf, in his book entitled The Una-flow Steam Engine, says: "The constant compression, always held to be a desideratum in large engines, is fundamentally false. It further follows that the distribution obtained by link motion and shifting eccentric gear is fundamentally correct, as it gives large compressions with early cut-offs and small compressions with late cut-offs."

To what extent the 90 per cent compression in uniflow engines exceeds the most economical compression can be seen from diagrams replotted from the aforesaid book of Professor Stumpf. For example, for an engine working with 170 lb. gage pressure, 197 deg. superheat, 27 in. vacuum, and a cylinder clearance of 2 per cent, the most favorable compressions for different cut-offs as taken from such a diagram, adiabatic compression being assumed, are as follows:

Cut-off, per cent	10	15	20	25
Compression, per cent	70	58	50	45

For other conditions of exhaust, i.e., less than 27 in. vacuum, a compression of still shorter duration should be maintained for the different cut-offs.

With these points in view, the author designed a uniflow engine and provided it with auxiliary exhaust valves and gear

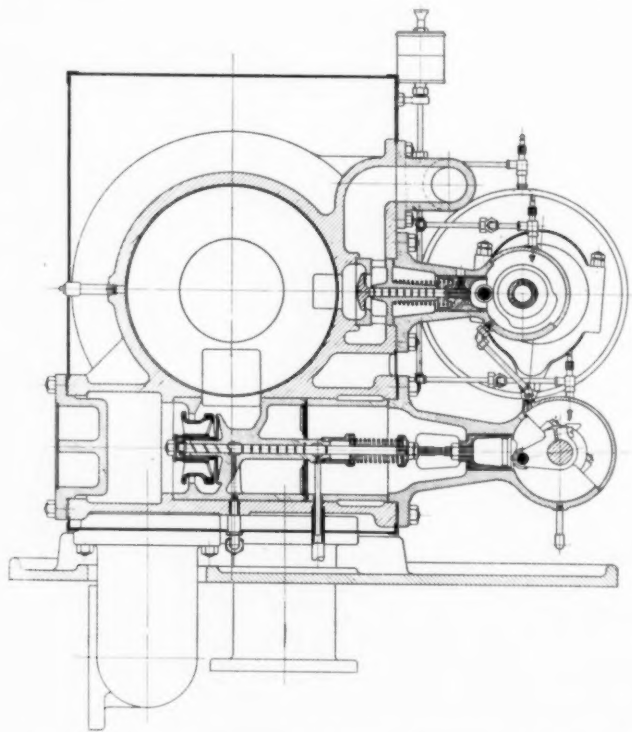

FIG. 7 EXHAUST VALVE, AUXILIARY EXHAUST VALVE, AND VALVE GEAR

controlling compression for any and all operating conditions.

The auxiliary exhaust valves are of small diameter, single-seated yet balanced, as they open under no difference in pressure on either side of the valve. The added clearance space due to these valves is negligible.

These auxiliary valves are operated by a continuously rotating camshaft (Fig. 7), an arrangement which has been adopted by the York Mfg. Co. The cams can be shifted on the shaft while the engine is in operation. A suitable disposition for release and compression can be obtained, for instance, by opening the auxiliary valves, say 7 per cent before dead center, closing them 30 per cent after dead center—equal to 70 per cent compression and recommendable for condensing work; while for non-condensing operation the cams can be shifted into the other extreme position, when the auxiliary valve opens about 7 per cent after dead center (the main exhaust port is still open) and closes about 15 per cent before the other dead center is reached. A compression ranging between 70 per cent and 15 per cent of the stroke is suitable for practically any working condition.

The camshaft is rotatably shifted by means of a handwheel, pin and spiral groove (Figs. 8 and 9), and clamped in the desired position. A dial indicates to the engineer for what degree of compression the cams are set. It is obvious that this device may be operated automatically by using instead of the handwheel a piston subjected to the difference of exhaust and atmospheric pressure.

On engines operating continuously condensing the auxiliary exhaust valves may be dispensed with and be replaced by valves which connect with the additional clearance space in case the vacuum fails, an arrangement adapted for the standard uniflow engine.

A uniflow engine without auxiliary exhaust valves and without side shaft has been developed by the author for driving the small high-speed ammonia compressors built by the York Mfg. Co., Fig. 10. Identically the same cylinder design is used as for the larger-size machines, but governor and eccentric are placed on the main shaft and the valves operated by means of a reciprocating camshaft.

One of the difficulties in poppet-valve engine construction is to design and manufacture the valve and seat in such a way that they expand equally and maintain steam-tightness under any other temperature than that at which they were ground together.

Good results have been obtained by making valve seats and valve proper of similar shape, likeness and material. However, such an arrangement is not always possible, and valves adjusting themselves to any expansion of the seats are often preferable.

In the design of the Ames Iron Works the upper seat is of thin, flexible steel, and by making the valve somewhat unbalanced this seat is pressed down by the steam pressure until the metallic surfaces meet. The original Stumpf design uses a valve made entirely of steel.

The author's design of a self-adjustable valve is shown in Fig. 11. Due to the peculiar construction of this valve, which is balanced to the same degree as any other standard poppet valve, the upper half will lift under an excess of pressure within the cylinder or in case of a slug of water, and thus constitutes a relief valve of extraordinary large area. As this feature is combined with the admission valve, its safe operation as a relief valve is absolutely insured and the difficulties usually encountered with relief valves avoided. The part of the valve effecting relief lifts only against steam pressure and a spring of light tension and is in no way affected by the tension of the main spring.

Another feature of this valve lies in the fact that it lifts

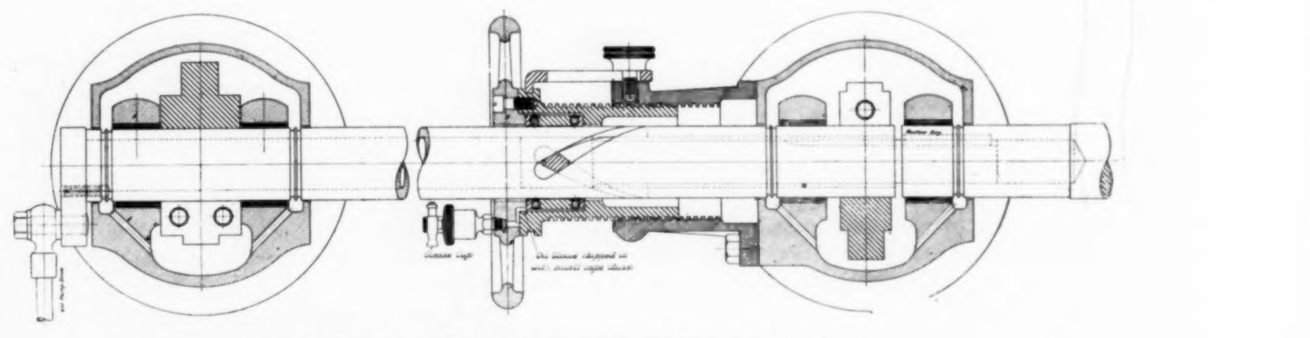

FIG. 8 VALVE GEAR FOR AUXILIARY EXHAUST VALVES

practically against no steam pressure, as pressures are equalized above and below the seats as soon as the lower valve part is lifted.

As this valve will adjust itself to any expansion of the valve seats, it can be ground in when the cylinder is cold and remains steam-tight under any temperature.

Fig. 12 shows cards taken from a uniflow engine with variable compression as made by the York Mfg. Co.

The Locomobile

Considerable favor has been given in the last few years to a very unique and compact power-plant arrangement—the so-called "locomobile," which is a combination of an engine placed on top of a boiler with a superheater, condenser, air pump, feedwater heater and feed pump. In other words, a compact, high-class and self-contained power plant which is extensively used in isolated plants and for farm purposes in Europe and South America.

The success of the locomobile is primarily due to the close combination of boiler and engine whereby heat is transformed into power on the shortest path possible. Designers of plants for stationary engines have nearly always sacrificed these thermal advantages to arrangements which were dictated by an exaggerated sense of safety and conservatism. The success of the locomobile fully demonstrates that a much closer arrangement of boilers and engines has become an economic necessity.

Remarkable economies have been obtained with these engines. Steam consumptions of 8 lb. and coal consumptions of 1 lb. per i.hp. per hour, in units of 100 to 200 hp., are nothing unusual in compound engines, and that with working conditions not exceeding 200 lb. pressure and 300 deg. fahr. superheat. Though these engines are particularly attractive in the smaller sizes, say, up to 300 hp., considerably larger units have been built by several German concerns. A Lentz locomobile of 1000 hp., built by Heinrich Lanz., of Mannheim, Germany, was exhibited at the World's Fair in Brussels in 1910.

In cross-compound engines of this type the two high-pressure admission valves are operated by one cam and one eccentric, the travel of which is regulated by the governor; while the two high-pressure exhaust and four low-pressure valves are operated by a single camshaft on which the three cams are mounted.

A somewhat simplified arrangement is obtainable by using the high-pressure exhaust valves also as admission valves to the low-pressure cylinder.

The cranks are set on 180 deg. and the indicator cards are typical of an engine without a receiver, a so-called "Woolf" engine.

Two very interesting tests carried out on such a type of engine are given herewith. They are noteworthy on account of the steam pressure and superheat carried and on account of the remarkable economies obtained.

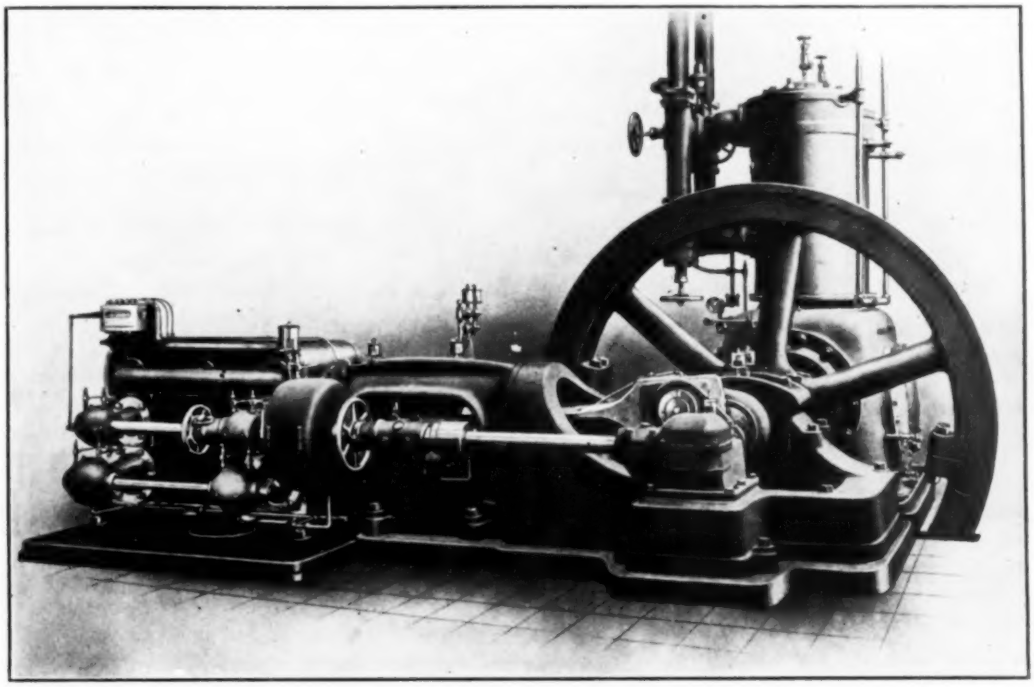

Fig. 9 Poppet-Valve Semi-Uniflow Steam Engine

Steam pressure, lb. per sq. in., gage	213	432
Temp. of high pressure steam, deg. fahr	923	1018
Indicated horsepower	112	99
Revolutions per minute	150	158
Vacuum, inches of mercury	27.7	26.7
Steam consumption per i.hp-hr. lb.	6.53	5.68
Heat consumption per i.hp-hr., B.t.u.	9720	86-0

It is interesting to compare these results with those obtained from a poppet-valve engine of the steam car of the White Motor Co., Cleveland, O., which was so successful before the modern development of the gasoline car set in.

Professor Carpenter, of Cornell, tested one of these engines and obtained with a steam pressure of 427 lb. and a steam temperature of 767 deg. fahr., operating non-condensing, an economy of 12.29 lb. per b.hp. per hr. These results can also be considered quite remarkable, especially in view of the fact that the bores of the high- and low-pressure cylinders were only 3 in. and 6 in., respectively, the stroke $4\frac{1}{2}$ in., and the speed 850 r.p.m.

The uniflow cylinders have also been used considerably in connection with locomobiles. Economically, however, the locomobile has shown no marked superiority over the return-flow

poppet-valve engine, as the heat losses peculiar to stationary engines are considerably reduced on account of the arrangement of the locomobile.

Simplicity of cylinder and valve-gear design, on the other hand, makes the uniflow locomobile a very attractive unit. Usually platforms and stairs are provided to give access to all parts. In some plants, especially where several units are installed, a floor is laid above the boilers, and in this way the boiler and engine rooms are separated.

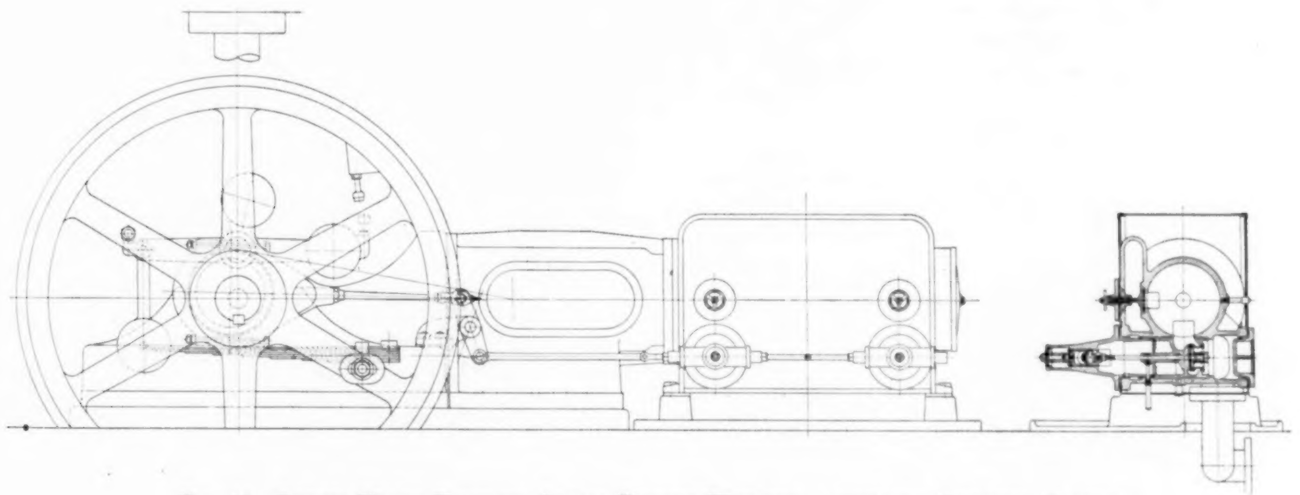

Fig. 10 Poppet-Valve Uniflow Steam Engine Without Auxiliary Exhaust Valves

THE MARINE ENGINE

In order to ascertain the applicability of superheated steam and poppet-valve engines to steamships, the Compagnie Générale Transatlantique, of France, ordered in 1905 from the navy yard of St. Nazaire, two cargo boats, the *Rance,* the two boilers of which were fitted with superheaters and the engines with poppet valves, and the *Garonne,* fitted with the ordinary type of marine engine without superheater.

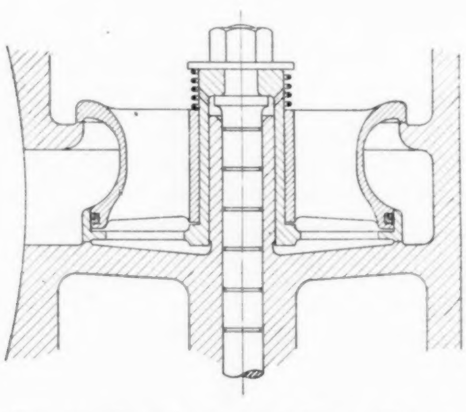

Fig. 11 Self-Adjustable Poppet Valve

Tests made under identical conditions showed that, due to the superheater and poppet-valve engines, an increase of power of 18.1 per cent and a decrease in coal consumption of 20.1 per cent were obtained.

A great simplicity of valve-gear arrangement is possible with these poppet-valve engines, as is apparent from a study of the cross-sections of some typical triple-expansion engines. These show not only a grand housecleaning of moving parts, but also very ingenious arrangements for the disposition of the valve-gear parts.

As a rule, separate steam engines are provided for reversing marine engines, but in this case the usual reversing engine is dispensed with and replaced by a hand-operated reversing gear, very little power being required.

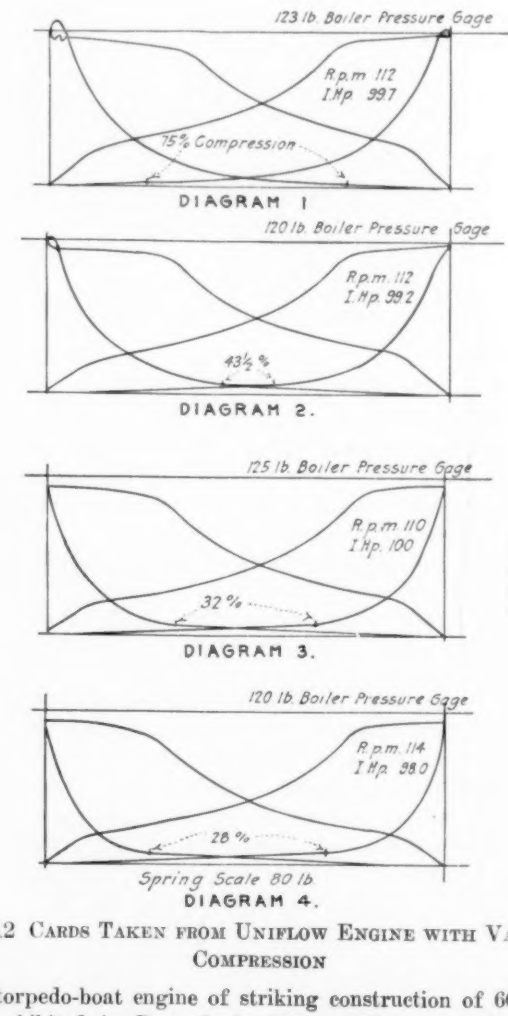

Fig. 12 Cards Taken from Uniflow Engine with Variable Compression

A torpedo-boat engine of striking construction of 6000 hp. was exhibited in Brussels in 1910. This engine is rather unique in its arrangement, being a compound engine having

three low-pressure and one high-pressure cylinders. All four cylinders and sixteen valves are of the same diameters, respectively. The corresponding valve-gear parts are alike for the different cylinders and for that reason are all interchangeable.

Uniflow cylinders have also been applied to marine engineering with considerable success in the last few years, on account of the simplicity of cylinder and valve-gear arrangement, enhanced by the fact that all cylinders belonging to one engine are exact duplicates.

The valves are mostly arranged in a horizontal position and operated by a valve gear of similar design to that used for stationary engines of the uniflow type.

THE LOCOMOTIVE

The first concern to equip locomotives with poppet valves was the Hannoversche Maschinenbau A. G., of Hannover, Germany. Preliminary tests were made in 1905 on an old tank locomotive which happened to be at the shops of this concern undergoing repairs. These tests were made after the old slide-valve cylinders were replaced by cylinders fitted with poppet-valves and Lentz gear.

The results were highly satisfactory to the advocates of poppet valves and superheat on locomotives, as with a steam temperature of 520 to 540 deg. fahr. the poppet-valve locomotive showed a saving in water to the extent of 30.6 per cent and a saving in coal of 19.5 per cent as compared with the slide-valve locomotive working with saturated steam.

On the small pilot locomotives and on the newest express locomotives the poppet valves are arranged horizontally and worked by cams mounted on a horizontal shaft which is oscillated from the eccentric rod by means of a small crank arm.

On the older express locomotives the four valves were placed in a vertical position above the cylinder, in a row one behind the other, the two admission valves toward the middle and the two exhaust valves toward the ends of the cylinder. The cam rod has four symmetrically arranged lifting curves which engage when in contact with the rollers on the valve spindles. The camshaft receives a reciprocating motion from the link gear and raises the valves alternately. The whole valve-gear box is removable from the cylinder, making inspection and replacing of parts a very simple matter.

Uniflow engines on locomotives have shown good results and seem to give better results than the return-flow poppet-valve engines at light and medium loads, while the superiority seems to rest with the latter type at the heavy loads.

It is difficult to say how many poppet-valve locomotives are in service now, but according to the author's information there were several hundred in operation in Germany before the war broke out, and a large number in England, France, Belgium, Austria, Switzerland, Russia, and also in the Scandinavian countries.

It is apparent from what has been said and shown in the foregoing pages that the modern development of the poppet-valve engine has revolutionized steam engineering and has made possible arrangements and working conditions and produced results which were, until recently, considered beyond reach.

Designers and manufacturers would do well to consider the importance and recognize the truth of the principles presented, as the conservation of our natural resources—which have been wasted to a lamentable extent for many years past—has become a matter of great cultural and economic importance.

CORRESPONDENCE

CONTRIBUTIONS to the Correspondence Departments of The Journal by members of The American Society of Mechanical Engineers are solicited by the Publication Committee. Contributions particularly welcomed are suggestions on Society Affairs, discussions of papers published in The Journal, or brief articles of current interest to mechanical engineers.

Mobile Armament for Defense

TO THE EDITOR:

In Mr. Coyle's paper on Mobile Armament for Defense, the importance of having some standards for calibers of guns was not mentioned. This feature is, of course, well understood by military men and provision is made for this to a certain extent, but not enough stress is laid on the matter.

The calibers, bores, breech mechanisms and firing devices for different types of guns should be so standardized that ammunition could be used by either the army or navy and, if possible, by the allies. That is to say, all revolvers and pistols are to have the same caliber and the same cartridges and all rifles are to use the same cartridges. All 1-lb., 3-in., 12-in., etc., projectiles are to be of the same outside dimensions to fit the corresponding-sized gun. This would simplify the problem of munition manufacture and be of vital importance in many cases where shortage of ammunition of a certain size might occur in action.

I have doubt about the practicability of the gun mentioned which has the breech plug sliding against a hardened curved surface. I think that in firing the gun the pressure or blow which would be caused by the discharge would roughen or dent the curved surface so much that the friction would give trouble in elevating and depressing the piece. With reference to the supports on arms shown in the diagrams, with the jackscrews at the ends, I think something on the lines of a tripod, well braced at the sides, designed on the trails for long-recoil field guns and siege howitzers, would give better satisfaction. This would take care of the horizontal fire; the high-angle fire could be taken care of by some substantial supports nearly under the trunnions of the gun.

The question of independent drive for armored trucks and cars of this kind is a very important matter and I am anxious to see something developed and put into commercial use along the line of explosive engines using alcohol instead of gasoline, as it will have to come to this sooner or later.

ARTHUR F. CARY.

Watertown, Mass.

Problems in Waste Disposal

TO THE EDITOR:

The writer considers that a wise choice was made when the reduction process was decided upon for the city of Chicago for the disposal of garbage, although there might be much

room for argument over the use of the drying (Mertz and Simons) method of reduction. For cities of large and moderate size any one of the three principal reduction methods mentioned may now be used to dispose of garbage in a sanitary manner and with freedom from nuisance. In general, reduction will be found to be much more economical and will show a decidedly higher percentage of successful installations in this country than will incineration. Incineration is the general method employed in Europe, but it has not attained success here because of different conditions encountered.

If service, cost and sanitary results were on a par between reduction and incineration for a given city, I should favor reduction because the question of conservation of our resources is involved. Reduction saves for us valuable products, returning fats and oils to the industries and plant food in the form of tankage to help enrich our soils, whereas incineration destroys and wastes them.

Concerning the author's statement that tankage and grease produced by the drying process are of better quality than by the cooking process as used at Cleveland, Columbus and elsewhere, it is interesting to compare prices received in 1917 for these products as follows:

	Drying Process	Cooking Process	
	Chicago.	Cleveland.	Columbus.
Grease, per cwt.........	\$7.29	\$8.01	\$7.52
Tankage, per ton........	7.00	10.00	11.00

The grease contracts of Chicago and Cleveland were made at about the same period, while the Columbus contract was made when the market was considerably weaker. In the case of tankage the Chicago price is the market price quoted by the author for Chicago and not the actual contract price. For Cleveland and Columbus the prices of tankage fluctuate slightly, being dependent on the analysis of the product, but will average about as given.

The author refers to Dr. Morgan's claim to a process for the production of alcohol from garbage. This process is particularly applicable as an addition to the cooking process of reduction and it has been the writer's privilege to have recently conducted practical tests on the process, during which tests a large amount of the technic of the process was developed. It may be said that the process is entirely practical but that its success financially at its present status is dependent upon market prices of alcohol and certain chemicals and upon the quality of the garbage treated.

Although different ideas may prevail concerning the methods and equipment used in the Chicago plant, much originality in arrangement and selection of apparatus has been shown, which should be beneficial to the industry. The plant should make an excellent record now, due to the fact that high prices for products prevail, and due also to the equipment being new and repairs and maintenance being at a minimum.

T. D. BANKS.

Columbus, Ohio.

WORK OF THE BOILER CODE COMMITTEE

The Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, Mr. C. W. Obert, 29 West 39th St., New York City.

Below are given the interpretations of the Committee as approved by the Council on July 15, 1917, in Cases Nos. 162-166 inclusive. In this report, as previously, the names of inquirers have been omitted.

CASE NO. 162

Inquiry: Is it permissible under the A. S. M. E. Boiler Code, that safety valves bearing all the markings called for by the Code, may be sold as conforming to Code requirements, when their lifting devices fail to raise the valves from their seats as required by Par. 282?

Reply: The Boiler Code requires that a safety valve be provided with a substantial lifting device and shall have the spindle so attached that the valve disc can be lifted from its seat not less than one-tenth of the nominal diameter of the valve when there is no pressure on the boiler. The Code does not specify the character of the lifting device.

CASE NO. 163

Inquiry: Does Par. 317 of the A. S. M. E. Boiler Code and the interpretation in Case No. 110 apply in the case of a boiler plant where duplicate feed lines are used, one of which conforms strictly with Par. 317, while in the other there are no stop valves between the check valves and the boilers?

Reply: It is the opinion of the Boiler Code Committee that Par. 317 of the Code is intended to mean that a valve shall be placed between the boiler and a feed check wherever a feed line is used.

CASE NO. 164

Inquiry: What is meant by the latter portion of Par. 207 of the Boiler Code which provides for greater spacing between rows of staybolts than indicated in Table 3? Is there not an inconsistency in the language that should be cleared up?

Reply: Par. 207 is designed to cover constructions in water-leg boilers where the portion of the sheet which comes between rows of staybolts is reinforced through the flanging-over of the edge of the handhole openings. It is evident that where the handhole openings are flanged to a depth of, say, twice the depth of the plate, that the transverse strength is increased over what it would be should there be no such flanging. In cases of this sort, the construction may be considered a beam fixed at each end, the beam to have a factor of safety of at least five.

CASE NO. 165

Inquiry: In view of Par. 274 of the Boiler Code, which states that only water heating surface, and not superheating surface, is to be considered in determining the minimum sizes of safety valves, an opinion is requested as to what portion of the tube surface of vertical tubular boilers shall be considered superheating surface.

Reply: It is the opinion of the Committee that for the purpose of determining the minimum sizes of safety valves to be used in vertical fire tube boilers, the tube surface above the center line of the upper gage cock should be considered as superheating surface. See Par. 274 of the Code.

CASE NO. 166

Inquiry: Is the maximum allowable working pressure of a locomotive boiler limited by Par. 194 of the Boiler Code, where a special flanged ring construction is used at the base of the dome instead of flanged dome sheet construction?

Reply: It is the opinion of the Boiler Code Committee that the construction referred to, involving special flanged ring construction independent of the dome sheet at the base of the dome, comes under Par. 261 of the Code and must conform thereto.

SOCIETY AFFAIRS

A Record of the Current Activities of the Society, Its Members, Council, Committees, Sections and Student Branches; and an Account of Professional Affairs of Interest to the Membership

WORK at headquarters has been as active during the hot weather and the so-called vacation period as at any time in the Society's history. Visitors from Russia, Australia, South Africa, South America and Japan have been received and special attention given them, as is the Secretary's custom.

We have for quite some time been trying to make the Society a medium for the interchange of technical knowledge and the development of cultural relations with other countries, and it is gratifying to see the extent to which the Society has succeeded.

Also, a large number of members have called. Several of the committees have been meeting regularly, notably the Committee on Engineering Resources, which, through the classification of the members, is furnishing all departments of the Government and the industries generally with names of specialists for any emergency. We have studied the classification systems of the Government, the insurance companies and the universities, and we think we have the most comprehensive of any. This service is free, and is the Society's contribution to the efficiency of the nation.

The progress on the alterations and enlargement of the Engineering Societies Building is satisfactory, and by the middle of October, if not sooner, quarters will be ready for the American Society of Civil Engineers.

Taking advantage of the construction period, this Society is having some much-needed improvements made in its quarters. All of the editorial and clerical rooms are being thrown into two large rooms and sound-deadening ceilings installed similar to those in the new portions of the building now under construction, and in modern offices generally.

The members on the Pacific Coast are looking forward to the visit of President and Mrs. Hollis in October. Another feature will be a Council meeting in November in Chicago, thus developing the contact between the representatives of the Society and the members.

CALVIN W. RICE,
Secretary.

WHAT THE SECTIONS HAVE DONE THIS YEAR

THE first of the Sections yearly reports were published in the August issue of THE JOURNAL, together with an account in general of the Sections activities throughout the past year. The spirit of coöperation developing among the Sections and the local branches of the other engineering societies was commented on at length as a sign favorable both to the Sections themselves and the Society nationally.

The reports published last month included those from Baltimore, Buffalo and New York. Similar reports have since come to hand from other Sections and are published below.

Next month the Committee on Sections will outline the proposed activities of the Sections for the coming season, and the month following the programs of coming Sections meetings will be announced.

ATLANTA

The meetings of the Section have been irregular, but approximately monthly, and a number have been held with the Affiliated Technical Societies of the City of Atlanta. The average attendance at these meetings is 30 per cent, but on special occasions as many as 75 per cent of the members are present.

Among the most important meetings held should be mentioned the following: On January 16 Ira N. Hollis, Pres.Am.Soc.M.E., addressed the Affiliated Technical Societies of Atlanta on the subject of the part being played by the Engineer and the Engineering Societies in Modern Life, appealing to them for concentration of efforts in the war against nature in the preparedness, conservation and promulgation of the country's welfare. Dr. Hollis laid great stress upon the efficient application of power, force and resources, showing very clearly to his audience the real value of the engineering societies and the results of their combined action, and the necessity of concerted action to obtain the highest efficiency in the general results of time, by the war against nature, so necessary to place the country in a state of preparedness which would enable us to use in the most efficient manner the natural, artificial and resourceful products of the country.

In March Lieut.-Col. Lytle Brown, Engr. Corps, U.S.A., gave a very interesting and instructive address on The Engineer in Modern War.

The membership also visited the works of the Atlantic Steel Co., on the invitation of the secretary and treasurer, who is a member of the Society.

OSCAR ELSAS,
Section Chairman.

BIRMINGHAM

Birmingham has had many meetings during the past year, which proved of much interest and help to those present.

The first took the form of an excursion to the Avondale Works of the Continental Gin Company and the plant of the Coyne and Joubert Foundry Company. Among the subjects of special interest at later meetings were The Use of By-Product Coke-Oven Gas as a Fuel and some of the Problems Presented in Its Use at the Ensley Steel Works, by W. P. Caine; The Manufacture of Cast-Iron Water Pipes, by Paul Wright; The Place of the Engineer and the Engineering Societies in Modern Life, by Dr. Ira N. Hollis; The Locomotive Firebox and Combustion Chamber, by J. J. Anthony; Illumination, by Prof. A. A. Wittig; Technical Writing, by Prof. M. Thomas Fullan.

During the year the hearty coöperation and support of the two state universities has been enlisted and two representatives from each have addressed the Section. The Section has also been influential in the organization of the Alabama Technical Association, which includes all the members of the national engineering societies residing in the state of Alabama, of whom there are over two hundred.

PAUL WRIGHT,
Section Chairman.

BOSTON

The season opened with a combination trip to New London for the inspection of submarine design, construction and operation, which was greatly enjoyed by some four hundred members and

friends from Boston, Worcester and Providence. The day included luncheon at the hotels, a trip down the bay on Government steamers, where surface and submerging practice was carefully watched, followed by a return to the works of the Electric Boat Company, at Groton.

The next meeting consisted of a trip to the General Electric Works at Lynn and a further inspection of the United Shoe Machinery Shops at Beverly, followed by a dinner at the clubhouse, with an illustrated lecture on the Turbo Drive for Ships, by W. L. R. Emmett, Mem.Am.Soc.M.E.

On February 7 the meeting consisted of the annual combined banquet, at which very interesting talks were given by Dr. Richard Cabot, who was preparing another hospital unit for France, and by E. W. Ewartz, who delivered an illustrated lecture on submarines. At this meeting a resolution was adopted and forwarded to the President of the United States endorsing his stand and offering the services of this Section. This was probably the most successful dinner ever held in the Boston Section and was attended by about five hundred members and guests.

The meeting held on March 8, under the A.I.E.E., covering electric transmission for vehicles both for the railroad and ordinary road work, was attended by our membership.

The Power Plant Meeting was held April 4 and 5 at the Engineers' Club and the Wentworth Institute, the meetings being held under the direction of Professors Hutton and Williston. Papers were read by several exponents of municipal and independent plants and descriptions given of some modern plant apparatus.

The spring meeting was held at Marblehead, April 17, where the hydroplane plant of the Burgess Company was inspected. In the evening, at Wentworth Institute, the Section was addressed by several engineers connected with this industry.

The season has been exceptionally interesting, not only on account of the increasing influence of engineering work in modern civilization, but also because of the enormous expansion of all the industries connected with the war.

A. L. Williston,
Section Chairman.

CHICAGO

The meetings during the past year have been well attended and a lively interest taken in the various subjects presented.

Four meetings were held during the season, the first and last being devoted to military subjects and the intervening gatherings to semi-technical topics such as oxy-acetylene welding and problems in waste disposal.

The dinner plan of meeting was continued, and for the first time the Section had a "ladies' night." This latter feature was a great success from a social point of view, and it is planned to continue it next year and also introduce innovations tending to enlarge acquaintances and bring the members closer together.

Joseph Harrington,
Section Chairman.

CINCINNATI

The Cincinnati Section is affiliated with the Engineers' Club of Cincinnati, an organization about 30 years' old. At three or four meetings a year the program of the Engineers' Club is carried out by the Cincinnati Section of the A.S.M.E. The chairman of the Section presides, the paper and its discussion being arranged by the officers of the Section. This provides an audience larger than the club could provide of itself.

At the present time the number of local members credited to Cincinnati in the 1917 year book is 94. There are, however, a number of members in St. Bernard, Norwood, Ivorydale, Ohio and Newport, Kentucky, who meet with the local members. In addition to these there have been quite a number of recent applications, which brings the total number of members in the Section to 135.

This Section has been fortunate in having speakers of prominence address the various meetings during the year, on subjects of much interest.

Among these was one on Some Present and Future Carburetion Problems, by C. F. Kettering, Mem.Am.Soc.M.E., and vice-president of the Dayton Engineering Laboratories Company. Mr. Kettering is largely responsible for the Delco lighting systems for motor cars and for the Delco-Light for small isolated electric lighting plants, and handled his subject in such an extremely interesting manner that he succeeded in holding his audience fascinated for two hours. Abner Doble, inventor of the Doble steam car, also gave an interesting paper, which has since appeared in The Journal, entitled The Steam Motor Car.

Much time was spent in making preparations for the Spring Meeting of the Society, one result of which was the Joint Meeting with The National Machine Tool Builders' Association on May 22, at which time papers were read by H. Schneider, Dean of the University of Cincinnati, on The Trend in Engineering Training, and by Dr. Otto P. Geier, on The Human Potential in Industry.

F. A. Geier,
Section Chairman.

DETROIT

A series of meetings of members of the Am.Soc.M.E. residing in Detroit and neighboring Michigan cities, led to the organization in October 1916 of this Section. It is the intention that this Section shall serve a territory around Detroit of approximately ninety miles radius.

It was decided to hold quarterly meetings which will not interfere with the meetings of the local associations. The Section's especial province seems to be to gather together the Society members of the district in order to bring them into contact not only with each other but with the leaders of the national organization; at the same time members of other engineering societies are invited to attend its meetings.

The two meetings held during 1917 were made of a social character. Members and their guests had dinner together before the meetings. Both were held at the Detroit Board of Commerce Building in order that the Section might become better known in the business life of the community. Members had the opportunity of listening to Ira N. Hollis, Pres.Am.Soc.M.E., and John W. Lieb, Mem.Am.Soc.M.E.

M. E. Cooley,
Section Chairman.

ERIE

The Erie Section has recently adopted the rule of holding at least four meetings a year, two to be dinner meetings at which the regular affairs of the Section will be taken up and two meetings will be held in conjunction with the Engineers' Society of Northwestern Pennsylvania, the Section to furnish the speakers.

The Section is one of the newest and regards its first year as one of experience. Adoption of the above program will ensure plenty of work for the coming season.

J. F. Wadsworth,
Section Chairman.

INDIANAPOLIS

The Indianapolis Section was organized in October and the first three meetings were devoted to the completion of this organization.

In February a meeting was held in conjunction with the A.I.E.E., at which Harrington Emerson, Mem.Am.Soc.M.E., spoke on Efficiency and the Engineer.

Several other meetings were planned, but were abandoned in order that the entire energies of the members might be devoted to preparedness work and the formation of a battalion of engineers.

Plans for the fall and winter are now being worked out and it is expected that there will be many discussions of interest.

W. H. Insley,
Section Chairman.

MINNESOTA

The Section has had some very interesting meetings in conjunction with the local branch of the A.I.E.E., and has also been honored with invitations from the Chemical Engineers and the Engineers' Club of Minneapolis. A very cordial feeling exists between the Minnesota Section and the other engineering interests and societies of the State.

This spring it was planned to join with the A.S.C.E. in a trip

to Duluth, Minn., but the war situation postponed the visit of the national society.

Probably the most successful meeting during the year was the Locomotive Session, when there were fifty railroad representatives in attendance and a large number of papers were read.

A banquet was also tendered Ira N. Hollis, Pres., Am.Soc.M.E., which was by far the biggest event of the year, and it may be noted in passing that the Am.Soc.M.E. is the only national society that has thus honored its sections.

The Committee on Sections has been urged to work out a plan whereby the more remote Sections may be able to meet and hear some of our most distinguished engineers.

The Section acts as a "big brother" to the Student Branch at the University of Minnesota and its influence with the students is evidenced by the interest they take in the Society and the possibilities of membership in it. Many of the students enter the Junior grade at the time of their graduation or shortly after.

A very important feature of the Section's activities is the means of bringing the local engineers together on a common basis and fostering by social contact a better understanding among those engaged in different engineering lines which could not well be accomplished in any other way.

The members of the Section were, on July 28, invited by Oliver Crosby, Mem.Am.Soc.M.E., to a picnic at his new home, "Stone-Bridge."

A large number of our members and their wives availed themselves of the opportunity to meet in a social way and all had a most enjoyable time. The fact was impressed upon the minds of those present that the engineers do not get a fair share of enjoyment out of life by a policy of "all work and no play," and it was noted that an affair of this kind offers a splendid opportunity to invite engineering friends, who may become better acquainted with the members, and in this way become interested in joining the Society.

The members are looking forward to the time when all the local engineering interests can be united so as to have a common meeting place and possibly an engineering society building.

J. V. Martenis,
Section Chairman.

MILWAUKEE

We have completed the best year of our existence, our meetings being largely attended. During the early part of the year, before we secured our present permanent quarters at the City Club, we found ourselves slightly handicapped, but are now enjoying an excellent attendance, aver ging over 150 members at each meeting.

The first meeting of the year, on September 13, 1916, was held at the plant of the Federal Rubber Company, Cudahy, Wis., under the direction of E. Hutchens, Mem.Am.Soc.M.E., who is supervising engineer of this company. L. J. D. Healey, chief chemist of the company, gave a talk on The Growing and Gathering of Rubber Latex. After the lecture the members were taken on an inspection trip around the plant. The Federal Rubber Company gave the Section a supper and showed moving pictures of the rubber industry. This was considered one of the best meetings we have ever held.

The next meeting held under our auspices was on October 11. Prof. J. G. Callan, of the University of Wisconsin, gave a very interesting talk on Recent Tendencies in Gas-Engine Design, illustrated with pictures of the latest types of automobile, aeroplane and submarine engines.

On January 6, I. N. Hollis, Pres.Am.Soc.M.E., gave a talk on The Place of the Engineer and the Engineering Societies in Modern Life.

William M. White, manager of the hydraulic department of Allis-Chalmers Mfg. Co., gave a talk on April 11 on Modern Hydraulic Turbines. There was a large attendance and Mr. White showed the audience views of the latest types of hydraulic turbines.

We try to arrange to have a supper for the speaker before each meeting, which is generally attended by the board of directors of our affiliated societies, and after the meeting a buffet luncheon is always served. We find that a great many of the members stay after these luncheons, standing about in groups and talking on various subjects, and in this manner become better acquainted than they would in any other way.

Edward Hutchens,
Section Chairman.

NEW HAVEN

While the conditions at New Haven do not offer opportunity for much coöperation, the Section has shown the greatest willingness to take advantage of any chance presenting itself. The meetings of the Section have been of service to the engineers of the whole state of Connecticut, and it is recognized that better results can be obtained through more systematic organization.

A Section for the state has been planned which will provide for the usual fall and spring meetings at New Haven and additional meetings at certain other localities in the state where Branches will be established.

Following the plan of former years, this Section has held two principal meetings. The Mining Department of the Sheffield Scientific School invited the Section to meet in the Hammond Laboratory in November, at which time the equipment of the mining laboratory was explained to those interested and a paper on Applied Metallography, by Prof. C. H. Mathewson, was read.

The evening session was held in the lecture room of the Mason Laboratory with F. B. Gilbreth, Mem.Am.Soc.M.E., and S. J. Berard as speakers.

The recently organized Winchester Engineering Club, composed of over 100 members of the engineering department of the Winchester Arms Company, was invited to join the New Haven Section in its spring meeting on April 19, 1917. This meeting was varied by an excursion to two of the pumping stations of the New Haven Water Company, and was followed by a dinner and social hour and an evening session with two illustrated papers on pumping engines for manufacturing purposes.

Informal local meetings have also been held and it is hoped that the new year will see much added interest.

H. B. Sargent,
Section Chairman.

NEW ORLEANS

The first year's work of the New Orleans Section has been a very successful one.

Due to there being in existence an active local engineering society at the time the Section was formed, it was considered best to hold but four meetings of the A.S.M.E. Section. These meetings were in every case held jointly with the local section of the Civil Engineers, and as the meetings were held in the rooms of the Louisiana Engineering Society and the members of that society were invited to attend, the meetings were in fact practically extra meetings of the latter society.

The tentative plan for next year is to have the Louisiana Engineering Society assign each of the local sections of the national societies a meeting at which some member of the section in charge will read a paper of special technical interest to the members of that society. The business meetings of the local sections will be held after the general meeting has adjourned. This plan has yet to be submitted to the societies interested, and approved.

The executive committee for next year will be: Chairman, R. L. Radcliffe; secretary, E. H. Tenney; E. Flad, W. A. Hoffman and H. R. Setz.

W. B. Gregory,
Section Chairman.

ONTARIO

As this Section is so new, having been established in May of this year, there is little to report in the way of sectional work. It might be mentioned that the mechanical engineers, through the local section, obtained representation on the Joint Committee of Technical Organizations.

Plans are being made for the coming year which we trust will prove of interest and value to all the members.

G. V. Ahara,
Section Chairman.

PHILADELPHIA

The activities of the Philadelphia Section during the past year have been marked by the coöperation which it has had with the other engineering societies of that city. In the first place the plan of affiliation of the Section with the Engineers' Club has

worked out very successfully and has many advantages to commend it. The Engineers' Club has become the headquarters for Section meetings and mail; the dining room of the Club is available for Section members, and when desired special dinners can be held there.

Besides the A.S.M.E. Section the local branches of the following organizations are affiliated with the Club: American Society of Civil Engineers, American Institute of Electrical Engineers, American Society of Heating and Ventilating Engineers, Illuminating Engineering Society, Society of Automobile Engineers, Massachusetts Institute of Technology and the Worcester Technology Club.

An advantage of the affiliation is the cordial intercourse developed between the engineering societies. During 1916-17 the A.S.M.E. Section held three joint meetings with The Franklin Institute and one with the American Society of Heating and Ventilating Engineers, while on May 14 at a dinner given to the speaker of the evening prior to the meeting by the local committee, the Section had as guests the chairman of nearly every engineering society represented in Philadelphia.

The subjects of the meetings we have held and the speakers are as follows: The Development of Our Fleet, by Wm. L. Cathcart, Mem.Am.Soc.M.E.; Aeroplane Engines, by C. E. Lucke, Mem-Am.Soc.M.E.; The Cooling of Water for Power Plant Purposes, by C. C. Thomas, Mem.Am.Soc.M.E.; Coke Ovens and Their By-Products, by C. J. Ramsberg; Design, Construction and Equipment of a Modern Military Aeroplane, by J. C. Hunsaker; District Heating, by Walter J. Kline; The Recent Development of the V-Notch Weir Measurement, by D. R. Yarnall, Mem.Am. Soc.M.E.; and Engineering of Men, by Willard Behan.

During the year the Proceedings of the Engineers' Club of Philadelphia has been developed until it has now become quite a pretentious journal. Each of the national societies is given a large page in each issue of the publication, and in that way members of all societies affiliated with the Club are made acquainted regularly with the proceedings of all engineering meetings held in Philadelphia.

EMMETT B. CARTER,
Section Chairman.

PROVIDENCE

There exists at Providence a situation different from any other local center of the Society's activities. There is no regularly organized Section of the A.S.M.E. in the city, but the functions of such a section are accomplished for the Providence members of the A.S.M.E. through the affiliation of the Society with the Providence Engineering Society. The local society has made considerable progress during the past year, first by securing adequate and permanent quarters and second, through the sub-division of the organization into sections under the following headings: Fire Prevention and Fire Protection, Machine Shop, Designing and Drafting, Efficiency, Structural Engineering, Chemical, Power, Municipal, Highway and Water Supply, Industrial and Technical Education, Student, and Municipal Engineering.

Each section held meetings monthly at which papers on suitable technical topics were presented and discussed, and it is felt that great benefit was derived by the members attending.

The general meetings of the society were held monthly and included in their programs such speakers as Dr. Miller Reese Hutchison, Prof. William S. Franklin, Dr. Ira N. Hollis, Mr. George H. Pegram, Mr. Harold W. Buck, Prof. Fred H. Newell, Mr. M. Marcel Knecht, University of Nancy, France, and Professor Von Hecke, University of Louvain, Belgium.

Letters were sent out this spring inviting other local engineering organizations and branches of the national societies to coöperate with the society for mutual advantage. The cordial way in which these invitations were received gives promise of closer relations in the future.

J. ANSEL BROOKS,
President.

ST. LOUIS

Dominating all of the activities of the St. Louis Section was the idea of arousing in the members a greater interest for subjects not related to professional work. Although conditions were not entirely favorable for carrying through such a program, the results obtained encourage further efforts in this direction.

During the season 1916-17 three Section meetings were held, besides four joint meetings with the Engineers' Club of St. Louis. In pursuance of this program the meetings were of a social character with a lecture treating more the human side of engineering or industrial life, while the joint meetings with the Engineers' Club were devoted to more strictly technical subjects.

The average attendance ran between 40 and 45 members, the attendance at the joint meetings being considerably higher. The larger turnout of our members at the Section meetings indicated a strong preference for non-technical affairs. The supper preceding the meeting proved an attraction and will be retained during the coming year. As a result of a canvass among our members it was decided to hold one such Section meeting every month, on a Friday evening.

Of the technical papers presented during the season, one on standardized boiler construction and another on Diesel engines brought out most discussion.

No extensive plans have as yet been decided upon for the activities of the coming year, except that a special effort is to be made to increase our membership. There is a growing feeling that more attention should be paid to the subjects touching upon the human side of the engineer's work. Considerable impetus would be given to such a movement if articles or papers on such subjects were published regularly.

H. R. SETZ,
Section Chairman.

WORCESTER

The season for the Section opened with the excursion to New London to visit the United States Naval Submarine Base, and also to inspect the plant of the Electric Boat Company. Many made the trip in automobiles, in addition to a good-sized delegation which went by special train from Worcester to New London.

The first meeting of the Section was held on November 14, 1916. President Jacobus was present, and his remarks concerning the activities and growth of the Society, which he illustrated by means of lantern slides, were thoroughly appreciated. Mr. Charles G. Washburn spoke on the Origin and Development of Leading Worcester Industries. It would be difficult to find one more qualified to speak on this subject than Mr. Washburn, and it was a privilege to hear from an authority the contributions which have emanated from Worcester and the vicinity—contributions to be classified as advancing the art of mechanical engineering.

The second meeting of the season was held on February 8, 1917, when Mr. Charles H. Norton, chief engineer of the Norton Grinding Co., spoke on the Introduction of Cylindrical Grinding and Worcester's Part in the Development of the Art.

The Secretary of the Society, Mr. Calvin W. Rice, was also present at this meeting and spoke on the affairs of the Society in general, and particularly upon the constructive work which was being accomplished under the presidency of Dr. Hollis.

The annual meeting was held on June 5, at which the officers for the ensuing year were elected. The delegates from Worcester who attended the annual Spring Meeting of the Society in Cincinnati were all present and told of the success which attended the efforts of the Cincinnati Section in conjunction with the Cincinnati members of the National Machine Tool Builders' Association. At this meeting announcement was also made that the Council had accepted the invitation of the citizens of Worcester to hold the 1918 Spring Meeting there. This announcement was received with enthusiasm. President Hollis addressed the meeting on Engineering Problems Relating to the War. His remarks were extremely interesting and an enthusiastic general discussion followed.

The last meeting of the season was held on June 28. By courtesy of *Machinery*, their motion-picture film representing the manufacture of 9.2-in. howitzer shells was shown. A portion of the film prepared by the Cincinnati Section, showing incidents connected with Spring Meeting, was also shown.

Interest in the work of the Society was well maintained during the winter months; the membership has increased through the activities of the Worcester Section, and there is every indication of a successful coming season.

GEORGE I. ROCKWOOD,
Section Chairman.

CANDIDATES FOR MEMBERSHIP

TO BE VOTED ON AFTER OCTOBER 10, 1917

THE American Society of Mechanical Engineers is an organization for mutual service of over 8,200 engineers and associates coöperating with engineers. The membership of the Society comprises Honorary Members, Members, Associates, Associate-Members and Juniors, all elected by ballot of the Council. Application for membership is made on a regular form furnished by the Secretary which provides for a statement of the standing and professional experience of the applicant and requires references from voting members personally acquainted with the applicant. The requirements for admission to the various grades will be furnished upon request.

Below is the list of candidates who have filed applications for membership since the date of the last issue of THE JOURNAL. These are classified according to the grades for which their ages qualify them, and not with regard to professional qualifications, i.e., the ages of those under the first heading place them under either Member, Associate or Associate-Member, those in the next class under Associate-Member or Junior, and those in the third under Junior grade only. Applications for change of grading are also posted.

The Membership Committee, and in turn the Council, urge the members to scrutinize this list with care and advise the Secretary promptly of any objections to the candidates posted. All correspondence in this regard is strictly confidential. Unless objection is made to any of the candidates by October 10, 1917, and providing satisfactory replies have been received from the required number of references, they will be balloted upon by the Council. Those elected will be notified about November 15, 1917.

NOTE. The Council desires to impress upon applicants for membership that under the present national conditions the procedure of election of members may be somewhat slower than under normal conditions. The first step in the consideration of an application is taken by the Membership Committee, and this committee is composed of busy men, with fewer opportunities to meet together in these strenuous times.

NEW APPLICATIONS

FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE MEMBER

Alabama

GARY, HARTWELL H., Superintendent, Ingalls Iron Works Co., Birmingham

Arizona

LEGRAND, CHARLES, Consulting Engineer, Phelps Dodge Corp., Douglas

California

ADAMSON, ARTHUR R., Assistant General Superintendent, Baker Iron Works, Los Angeles

BURNHAM, CHARLES, Superintendent and Manager, Burnham Basket Co., Los Angeles

MALONEY, GEORGE B., Chief Engineer, Associated Pipe Line Co., San Francisco

PIKE, ROBERT D., Chemical Engineer, San Francisco

THOMPSON, NELSON W., Chief Engineer, Simplex Refining Co., San Francisco

Colorado

WOOD, FRANKLIN P., Engineer, Franklin P. Wood & Co., Trinidad

Connecticut

BEDWORTH, ARTHUR H., Plant Engineer, Remington Typewriter Co., Bridgeport

BEGG, THOMAS K., Mechanical Superintendent Manufacturing Departments, Bridgeport Brass Co., Bridgeport

BENTLEY, JOSEPH H., Chief Draftsman, H. E. Harris Engineering Co., Bridgeport

BLOOD, BRYANT H., General Manager, Pratt & Whitney Co., Hartford

CAHILL, ANTHONY M., Equipment and Process Engineer, Winchester Repeating Arms Co., New Haven

CHERRY, JOHN D., Sales Manager, The Roto Co., Hartford

KRUCKLIN, WALTER, Tool Designer, Draftsman, Remington Arms U. M. C. Co., Bridgeport

WHEELER, CHARLES A., Professor and Engineer, Connecticut Agricultural College, Storrs

WHITNEY, ELMAR H., Assistant Wage Rate Supervisor, Remington Arms & Ammunition Co., Bridgeport

District of Columbia

LANDVOIGT, THOMAS E., Acting Heating, Ventilating and Sanitary Engineer, District of Columbia, Washington

Georgia

COVERDALE, E. J., Atlanta

HOLTZCLAW, BENJAMIN W., Chief Engineer, J. S. Schofield's Sons Co., Macon

LINDLEY, HARRY E., Chief Draftsman, L. W. Robert, Jr., Engineer, Atlanta

Illinois

BOSE, KUMUDINI K., Draftsman, Mechanical Department, Armour & Co., Chicago

BURR, ELLIS M., President, The Burr Co., Champaign

DEAN, RAYMOND S., Sales Engineer, Manning, Maxwell & Moore, Chicago

DREXELIUS, H. COREY, Designer of Automobile Machinery, Elgin National Watch Co., Elgin

GERARD, FRANKLIN B., General Superintendent, German-American Portland Cement Works, La Salle

HASKINS, HAROLD L., Engineer, International Harvester Co., Chicago

HOEFER, C. A., President, Hoefer Manufacturing Co., Freeport

JONES, DAVID J., Mechanical Inspector, Illinois Central Railroad Co., Chicago

SORENSEN, CLAUDE S., Special Machine Design, Western Electric Co., Chicago

Indiana

MILLHOLLAND, WILLIAM K., President and General Manager, W. K. Millholland Machine Co., Indianapolis

WOOD, DAVID W., President and Manager, Wood Turret Machine Co., Brazil

Kansas

SULLIVAN, WILLIAM L., Machinery, Power Outfits and Supplies, Pittsburg

Kentucky

MITCHELL, ALGIE R., Chief Draftsman, Andrews Steel Co., Newport

Maine

TODD, WILLIAM N., Electrical and Elevator Engineer, The Portland Co., Portland

CHIFFELLE, FRANCIS A., Engineer, Lewiston Bleachery & Dye Works, Lewiston

Maryland

BECK, WILLIAM H., Electrical Engineer, Crown Cork & Seal Co., Baltimore

CRONIN, FRANK H., Superintendent Mechanical Division, Water Department, Baltimore

Massachusetts

BEYER, David S., Manager Safety Engineering Department, Massachusetts Employees Ins. Assoc., Boston
BOLTON, Fred C., Third Assistant Foreman, New England Westinghouse Co., Springfield
CHASE, Nathaniel S., Chief Draftsman, W. T. Henry, C.E. and M.E., Fall River
COTTRELL, Abraham F., Jr., Assistant Superintendent, Hollingsworth & Vose Co., West Groton
DODGE, George W., Consulting Engineer, Holyoke
DORMAN, Edson R., Engineering, Contract Work, Greenfield Tap & Die Corp., Greenfield
DOTEN, William L., Mechanical Engineer, The Lamson Co., Boston
HARRIS, H. Patterson, Sales Manager, Worcester Pressed Steel Co., Worcester
HARRIS, William A. Jr., Assistant to Foreman, Gauge Manufacturing Department, New England Westinghouse Co., Springfield
KENDALL, Horace C., Assistant Manager and Purchasing Agent, Rockwood Sprinkler Co., Worcester
LENTZNER, Karl S., Experimental Engineer, The Norton Co., Worcester
LOEBER, Charles, Inspector and Estimator, Stone & Webster Engineering Corp., Boston
MANNION, Chester H., Chief Engineer and Electrician, American Thread Co., Kerr Mills, Fall River
SILCOX, Arthur E., Expert Mechanical Problems, Saco-Lowell Shops, Lowell
STONE, Thomas D., Contracting Engineer, Nightingale & Childs Co., Springfield
VAUGHAN, John F., Private Practice, Boston
VEDDER, J. Warren, General Manager, Rice, Barton & Fales M. & I. Co., Worcester

Minnesota

BROOKE, William E., Professor and Head Department Mathematics and Mechanics, University of Minnesota, Minneapolis
FOSTER, Charles, Manager St. Paul Office, Charles L. Pillsbury Co., St. Paul
MARSHALL, Ernest, Electrical Engineer, Great Northern Railway, St. Paul
SMITH, Paul D., Mechanical Engineer, Minneapolis Steel & Machinery Co., Minneapolis

Mississippi

FREEMAN, Henry L., Professor of Mechanical Engineering, Mississippi A. & M. College, Agricultural College

Missouri

FERGUSON, James W., Supervisor Mechanical Goods, Sales, St. Louis District, Goodyear Tire & Rubber Co., St. Louis
MORSE, Henry S., Assistant Superintendent Maintenance and Construction, St. Joseph Lead Co., Herculaneum
SHARP, Abia J., Proprietor and Manager, Harrisonville Foundry & Machine Works, Harrisonville
WILCOX, Frank L., Consulting Engineer, Municipal Work, St. Louis

New Hampshire

THOMPSON, Herman, Superintendent Mechanical Department, Amoskeag Manufacturing Co., Manchester

New Jersey

CAMPBELL, Norman St. G., Teaching, Registrar, Kingsley School, Essex Fells
DAVIDS, William C., Special Engineer, Duesenberg Motors Corp., Edgewater
FEIEREISEL, Frank A., Manufacturing Manager, De Laval Steam Turbine Co., Trenton
FISHER, Edward C., Manager, Cooke Works, American Locomotive Co., Paterson
JOHANNSEN, Odd K., Designer Centrifugal Pumps, A. S. Cameron Steam Pump Works, Phillipsburg
MURPHY, John Jr., Assistant Superintendent, United Piece Dye Works, Lodi
ROOT, Harold D., Machine Designer, Crocker-Wheeler Co., Ampere
VOLKHARDT, Charles E., Industrial Engineer, H. L. Gantt, Trenton

New York

ALDEN, Clarence T., Manager, Edison Electric Light & Power Co., Amsterdam
BANASH, James J., Service Engineer, Underwriters' Laboratories, New York
CARMAN, Joseph F., Chief Engineer, Abraham & Straus, Brooklyn
COLEMAN, J. Emile, Efficiency Engineer, The Mergenthaler Linotype Co., Brooklyn
DOVE-SMITH, Joseph, Proprietor, Dove-Smith & Son, Niagara Falls
FORSTER, Samuel S., Superintendent "Sec C," General Electric Co., Schenectady
GERDES, Henry T., President, Gerdes & Co., Inc., New York
HIMMELSBACH, Joseph, Consulting Engineer and President, American Packing House Engineering Co., New York
IRWIN, Oliver C., Refrigerating Engineer, Frick Company, New York
LANG, Johan G. V., Consulting Engineer, New York
MACKENZIE, Kenneth G., Consulting Chemist, The Texas Co., New York
MILLER, Jesse F., Chief Engineer, Department of Public Buildings, Albany
MOORE, William J., Assistant Professor of Mechanical Engineering, Polytechnic Institute of Brooklyn, Brooklyn
MUIR, Roy C., Commercial Engineer, General Electric Co., Schenectady
PARTINGTON, James, Estimating Engineer, American Locomotive Co., New York
POWELL, William B., Partner, Cundall & Powell, Consulting Engineers, Buffalo
RAPP, Conrad H., Assistant Manager, Designing and Engineering Department, Hoggson Brothers, New York
RICHARDSON, Joseph W., President, Nicholas Iron Works, New York
SAMES, Charles M., Associate Editor, American Society Mechanical Engineers, New York
SCHACHAT, Abraham B., Charge of Shop, Slocum, Avram & Slocum Laboratories, New York
SPINNLER, Charles E., Agent for Franco Tosi, Legnano, Italy, New York
STAEGE, Stephen A., Consulting Hydraulic and Electrical Engineering, Staege & Dewey, Watertown
SUPPLEE, Warren P., Chief Operating Engineer of Power Stations, The Eastern Penn. Lt., Heat & Power Co., the J. G. White Co., New York
TIZLEY, Arthur J., General Superintendent, E. F. Caldwell & Co., Inc., New York
VANDERBEEK, Herbert C., Head Master Boys, Masonic Home, Utica

North Carolina

BAHNSON, Frederic F., Engineer and Secretary, Normalair Co., Winston-Salem

Ohio

CHAMPION, David J., President, The Champion Rivet Co., Cleveland
EMERSON, Earl A., Export Manager, The American Rolling Mill Co., Middletown
FERGUSON, John L., Assistant Superintendent, The Quaker Oats Co., Akron Plant, Akron
JOHNSON, Frank Y., Designing Engineer, The Youngstown Sheet & Tube Co., Youngstown
LAWSON, Fenton, President, The F. H. Lawson Co., Cincinnati
NORDHOLT, John B., Vice-President, The Toledo Steel Casting Co., Toledo
WAREAM, Charles E., Chief Engineer, Development Department, The American Laundry Machinery Co., Cincinnati
YORK, Raymond D., Vice-President and General Manager, The Plymouth Street R. R. & Lt. Co., Portsmouth

Pennsylvania

ALEXANDER, J. S., General Manager and Mechanical Engineer, Philadelphia
DUFFY, Frank J., Major 1st Regiment Penn. Engineers, Philadelphia
FRANKLIN, Milton W., Consulting Engineer, E. F. Houghton & Co., Philadelphia
JULSTEDT, Chas. J., Engineer-in-Charge, Ordnance Drafting Room, Bethlehem Steel Co., South Bethlehem
McDEVITT, William J., Foreman, Fayette R. Plumb, Inc., Bridesburg
McMENAMIN, Charles G., Enginehouse Foreman, Pennsylvania Railroad Co., Philadelphia
PAYNE, Francis H., Manager, Metric Metal Works of American Meter Co., Erie
PEEBLES, Rodney A., Mechanical Engineer, Westinghouse Elec. & Mfg. Co., E. Pittsburgh
SANDERSON, Victor L., Sales Manager, Terry Steam Turbine Co., Philadelphia
SMITH, Josiah H., Mechanical Engineer, Ballinger & Perrot, Philadelphia
SNYDER, J. E., Superintendent Steam Turbine Erecting and Testing, Westinghouse Elec. & Mfg. Co., E. Pittsburgh
WETHERILL, William C., Vice-President, Keystone Screw Co., Philadelphia
McKEE, Thomas C., Assistant Chicago Manager and Sales Engineer, Carbondale Machine Co., Carbondale

Tennessee

MOSELEY, WILLIAM S., Mechanical Engineer,
C. C. & O. Railway, Erwin
PEEK, HORACE H., Treasurer and Manager,
Lookout Boiler & Mfg. Co., Chattanooga
TRAPNELL, JOHN M., Engineer in Charge Structural Department,
Walsh & Weidner Boiler Co., Chattanooga

Texas

FITZGERALD, CHARLES, JR., Assistant Chief Engineer,
Gulf Pipe Line Co., Houston
MCFARLAND, ARTHUR, Master,
U. S. Engineer Department, Port Arthur

Virginia

ASHBY, CHESTER, Charge Man, Engineering Department,
Newport News Shipbuilding and Dry Dock Co., Newport News
PENNING, NICHOLAS J., Assistant Power Engineer,
"B" Plant Power House, Du Pont Co., City Point

West Virginia

BRADY, HUGH S., Superintendent,
Hazel-Atlas Glass Co., Wheeling

Wisconsin

KIRCALDIE, WILLIAM I., Engineering Staff,
American Appraisal Co., Milwaukee
LEASE, LEONARD J., Electrical Engineer,
Allen Bradley Co., Milwaukee
VAUGHN, FRANCIS, with Vaughn & Meyer, Milwaukee

Canada

CHRISTENSEN, JAMES C., Superintendent,
Canadian Fairbanks-Morse Co., Ltd., Toronto
CLEATON, REINALLT E., Manager,
The R. E. Cleaton Co., Montreal
ESTLER, HARRY S., Manager, Sash Department,
Trussed Concrete Steel Co., Walkerville
JOHNSTON, CHARLES H., Superintendent of Munitions,
John Inglis Co., Toronto

Cuba

LOWELL, WALTER D., Advisory Engineer,
Punta Alegre Sugar Co., Central Florida

FOR CONSIDERATION AS ASSOCIATE MEMBER OR JUNIOR

California

DAVIS, ARTHUR C., Mechanical Engineer,
Los Alamitos Sugar Co., Los Alamitos
GOODWIN, GUY L., Engineer and Superintendent,
Refinery & Gasoline Plants,
Pinal Dome Oil Co., Santa Maria
JOHNSON, HAROLD S., Lieutenant, Coast Artillery Corps,
United States Army, Mill Valley

District of Columbia

DARNALL, JAMES C., Mechanical Draftsman,
Ordnance Office, U. S. Navy Yard, Washington

Illinois

NUTTALL, FRANK A., Erecting and Assembly Foreman,
Link Belt Co., Chicago
ZIMMERMAN, FRED R., Mechanical and Industrial Engineer,
Illinois Engineering Co., Chicago

Indiana

GRISBAUM, LEONARD D., District Manager,
Dravo-Doyle Co., Indianapolis
KRANNERT, HERMAN C., Manager Anderson Plant,
Sefton Manufacturing Corp., Anderson
RAISIG, CHARLES L., Plant Engineer,
P. H. & F. M. Roots Co., Connersville

Massachusetts

BOYNTON, WINFRED S., Mechanical Engineer,
The Lamson Co., Boston
CARTER, CLIFFORD R., Industrial Engineer,
Scovell, Wellington & Co., Boston
ELIN, MICHAEL B., Engineer,
New England Westinghouse Co., Chicopee Falls

Michigan

FRICKER, JACOB E., Mechanical Engineer, Plant Superintendent,
Air Reduction Co., Detroit

New Jersey

SAYRE, LESLIE A., with Crocker, Wheeler Co., E. Orange

New York

FERGUSON, LOUIS S., District Engineer and Sales
Representative,
The Permutit Co., New York
MOLOKIE, STEPHEN W., Draftsman,
Combustion Engineering Corp., New York
SANFORD, SELDEN B., Engineer in Charge of Testing,
Otis Elevator Co., Yonkers
SHUMARD, FRED W., Chief Draftsman,
Savage Arms Corp., Utica

Ohio

ROYER, EARL B., Engineer,
With Walter G. Franz, Consulting Engineer, Cincinnati

Pennsylvania

BALSINGER, HARRY D., with American Steel Foundries, Sharon
EVANS, ANDREW B., Layout Engineer,
Westinghouse Electric & Mfg. Co., E. Pittsburgh
JENKINS, DAVID J., Junior Fuel Engineer,
U. S. Bureau of Mines, Pittsburgh

Virginia

LAFON, ALPHONSE, Candidate Officers' Reserve Corps, Fort Myer

FOR CONSIDERATION AS JUNIOR

California

LEH, CLARKE F., Constructing Engineer,
E. B. & A. L. Stone Co., San Francisco
GRIFFITH, EARL G., Assistant Sales Engineer,
Meese & Gottfried Co., Los Angeles

Connecticut

COLVIN, DELANCY W., Planning Section Cartridge Department,
Winchester Repeating Arms Co., New Haven
EGLEE, CHARLES H. JR., Industrial Engineer's Staff,
Gun Department Winchester Repeating Arms Co., New Haven
WHITCOMB, HERBERT H., Mechanical Engineer,
Scovill Mfg. Co., Waterbury

District of Columbia

SCHLINK, FREDERICK J., Associate Physicist,
National Bureau of Standards, Washington

Illinois

FEERY, BERNARD T., Chief Draftsman,
Webster Engineering Co., Chicago
MALCOLMSON, WILLIAM J., Supervising Manufacturing Engineer,
Western Electric Co., Chicago

Indiana

BOYD, LANDON B., Production Engineer,
Advance-Rumely Co., La Porte

Massachusetts

KLEIN, FREDERICK H., Tool & Machine Designer,
Becker Milling Machine Co., Boston
LYON, RAYMOND F., General Manager,
Cowan Truck Co., Holyoke
MARSHALL, HAROLD F., Aviation Student,
U. S. Army School of Military Aeronautics,
Mass. Inst. of Tech., Cambridge

Michigan

KARR, CHARLES L., Assistant Chief Engineer Power Plants,
The Detroit Edison Co., Detroit
SLOMAN, CHERI M., Designer, Detroit

Missouri

MARTIN, ELMER C., Engineering Accountant, Kansas City

Nebraska

MILES, DALES S., Draftsman, Valuation Department,
C., B. & Q. R. R., Lincoln

New Jersey

KENNEDY, GRAFTON S.,
with Standard Aero Corp., Plainfield
MUNYAN, EARL A., Assistant Naval Inspector Powder E. C.,
Bureau of Ordnance, Navy Department, Jersey City

New York

CONBOY, RAYMOND G., Assistant to Superintendent,
August Mietz Corp., New York
FAIRFIELD, JOHN G., Assistant in Mechanical Engineering,
Rensselaer Polytechnic Institute, Troy
GARDNER, DOUGLAS M., Engineer,
S. S. Hepworth Co., New York
JACOBS, HENRY L., Student, Columbia University, New York
JOHNSON, JAMES W., Head of Industrial Analysis Department,
Carter, Macy & Co., Inc., New York
PARSONS, HENRY S., Superintendent,
E. R. Ladew Co., Inc., Glen Cove
WILLIAMS, PAUL, Experimental Engineering,
H. H. Franklin Mfg. Co., Syracuse
WITZELL, PAUL J., with Charles William Stores, Brooklyn

Ohio

GARDNER, THOMAS, Stirling Drum Department
Babcock & Wilcox Co., Barberton
WILLIAMS, BERKELEY, Engineer,
F. H. Lawson Co., Cincinnati

Oklahoma

AUERSWALD, HOWARD R., Assistant Manager, Gas, Water and
Construction Department,
Gypsy Oil Co., Tulsa

Pennsylvania

BARNES, Wilbur J., Efficiency Engineer, The Harwood Electric Co., Hazleton

BICKLEY, John H., Field Engineer, H. Koppers Co., Pittsburgh

BOONE, H. Searles, Electrical Engineer, L. F. Schoemaker & Co., Pottstown

CULLINEY, John E., Superintendent Employment and Safety Department, Bethlehem Steel Co., Lebanon

MILLARD, S. J., Instructor in Industrial Engineering, So. Brownsville High School, So. Brownsville

Rhode Island

DURSIN, Henry, Jr., Superintendent, Lafayette Worsted Co., Woonsocket

Cuba

WEBRE, Sylvestre J., Experimental Engineering, Cuban American Sugar Co., Delicias

Hawaii

GIBB, James A., Efficiency Engineer, Honolulu Iron Works Co., Honolulu

APPLICATION FOR CHANGE OF GRADING

PROMOTION FROM ASSOCIATE

Louisiana

ANDERSON, James Jr., Superintendent Pipe Line Department, Standard Oil Co. of La., Shreveport

PROMOTION FROM JUNIOR

Illinois

SINGH, Nand, Sales Engineer, International Harvester Corp., Chicago

WALTERS, William T., Mechanical Inspector Building Departmt., I. C. R. R.

Louisiana

NELSON, Bernard S., Engineer and Construction Superintendent, A. M. Lockett & Co., New Orleans

New York

DOYLE, Joseph A., Vice-President, W. S. Rockwell Co., New York

FINKEL, J. J., Inspection Engineer, New England Westinghouse Co., Springfield

GITHENS, Thomas F., Mechanical Designer, Chile Exploration Co., New York

WILLIAMS, Harold J., Instructor Applied Mechanics, Pratt Institute, Brooklyn

Pennsylvania

BENNETT, Ralph M., Superintendent, Frankford Arsenal, Bridesburg

SUMMARY

New Applications	209
Applications for change of grading:	
Promotion from Associate	1
Promotion from Junior	8
Total	218

Member's Pin Found

A member's catch pin has been found in New York City. It is being held in the Society's offices and upon identification will be returned to owner.

ROLL OF HONOR

To the lists already published of those members of the Society who have enlisted in the national service is added the following supplement:

Baird, Lyman S., First Lieutenant, Aviation Section, Signal Corps, U. S. A.

Baldwin, Bert L., Major, Officers' Reserve Corps.

Belcher, P. W., First Lieutenant, Engineer Officers' Reserve Corps.

Boardman, A. Jay, Captain, Ordnance Department, Officers' Reserve Corps.

Brayton, Harold M., First Lieutenant, Ordnance Department, Officers' Reserve Corps.

Briggs, Leroy E., Captain, Ordnance Department, Officers' Reserve Corps.*

Brill, George M., Major, Engineer Officers' Reserve Corps.

Byron, Leroy T., Chief Petty Officer, U. S. Naval Reserve Force, Brooklyn Navy Yard.

Case, Milo M., Captain, Engineer Officers' Reserve Corps.

Conant, William S., Ordnance Department, Officers' Reserve Corps.

Cronemeyer, Henry C., First Lieutenant, Engineer Officers' Reserve Corps.

Dallis, Park R., Captain, Engineer Section, Officers' Reserve Corps.

Diemer, Hugo, Major, Ordnance Section, Officers' Reserve Corps.

Doud, Willard, Lieutenant, Junior Grade, U. S. Naval Reserve Force, Naval Training Station, Great Lakes, Ill.

Eichenberg, Mark A., Ordnance Department, Officers' Reserve Corps.*

Farrell, Morgan G., First Lieutenant, Engineer Officers' Reserve Corps.

Field, Crosby, Lieutenant, Ordnance Department, U. S. A. Inspection Division.

Gilbert, Huntly H., Captain, Ordnance Department, Officers' Reserve Corps.

Gillam, William H., First Lieutenant, Officers' Reserve Corps, Ordnance Department.*

Greenwald, Louis, Electrician Sergeant, Fort Totten, N. Y.

Guiteras, Julian G., Lieutenant, Company I, P. O. Battalion, Fort Leavenworth, Kansas.

Hazlehurst, James N., Major, Engineer Section, Officers' Reserve Corps.

Henley, Erl K., Lieutenant, Junior Grade, United States Naval Reserve Force.

Hirsch, Gustav, Major, Signal Officers' Reserve Corps.

Jackson, John R., Captain, Ordnance Department, Officers' Reserve Corps.

Jellum, Kristen, Second Lieutenant, Engineer Officers' Reserve Corps.

Kaelin, Charles G., Captain, Ordnance Department, Officers' Reserve Corps.*

Keep, Henry, Major, Engineer Officers' Reserve Corps.

Keller, Parry, First Lieutenant, Ordnance Department, Officers' Reserve Corps.

Kenrick, Alfred E., First Regiment, Mass. Engineers' National Guard.

Knerr, Lewis E., First Lieutenant, Engineer Officers' Reserve Corps.

Knoebel, Carl B., Company F, 1st Infantry, Texas National Guard.

Kunze, Edward J., Captain, Quartermaster Department, Officers' Reserve Corps.

Lent, Leon B., Captain, Aviation Section of Signal Corps, active duty Curtiss Aeroplane Co., Buffalo, N. Y.

Lyman, Elihu E., Captain, Ordnance Department, Officers' Reserve Corps, Frankford Arsenal.

Lynch, Frank J., Aviation Section, Signal Officers' Reserve Corps, Texas University.

Lynde, Charles C., First Lieutenant, Engineer Officers' Reserve Corps.

McClintock, Allen P., First Lieutenant, Ordnance Section, Officers' Reserve Corps.

MacGill, Charles F., Ordnance Department, Officers' Reserve Corps.*

Martin, Kingsley G., Captain, Officers' Reserve Corps, Motor Transport Service.

Mosman, Ernest, First Lieutenant, Ordnance Department, Officers' Reserve Corps.

Rettig, George P., Office of Army Inspector, Signal Service at Large as Inspector of Airplanes and Airplane Engines.

Sees, Joseph S., Captain of Ordnance, Officers' Reserve Corps, Assistant Superintendent of Small Arms Ammunition, Frankford Arsenal.

Selfridge, Samuel W., Second Lieutenant, Field Artillery, Officers' Reserve Corps.

Selser, T. W., First Lieutenant, Engineer Officers' Reserve Corps.*

Scott, Rossiter S., Captain, Engineer Officers' Reserve Corps.

Slade, Arthur J., Aeronautical Division of the Signal Corps.

Swift, Harley L., Lieutenant, Officers' Reserve Corps.

Tag, Walter, Ordnance Reserve Corps.

Taylor, William T., Captain, Royal Flying Corps.

Tilson, Howard, Captain, Ordnance Department, Officers' Reserve Corps.

Trego, A. C., Lieutenant, Springfield Armory, Springfield, Mass.

Vogt, Clarence W., First Lieutenant, Ordnance Department, Officers' Reserve Corps.

Walker, Perley F., Major, 314th Regiment, National Army, Fort Riley, Kan.

Webster, Lawrence B., Captain, Ordnance Department, Inspection Division, Officers' Reserve Corps.

Whipple, C. Earl, Captain, Engineer Officers' Reserve Corps.

Whitlock, Elliott H., Eng. Co., 9th P.T. Regiment, Ft. Leavenworth, Kan.

Williams, Fay B., First Lieutenant, Ordnance Department, Officers' Reserve Corps.

Williams, Silas, First Lieutenant, Ordnance Department, Officers' Reserve Corps.

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*Acceptance of commission pending at date of latest list from War Department.

NECROLOGY

FRANK LEWIS BIGELOW

Frank L. Bigelow was born in New Haven on September 21, 1862. He was educated in New Haven, attending Hopkins Grammar School and later Yale University. He was graduated from Sheffield Scientific School with the class of 1881, having specialized in dynamical engineering.

Upon graduation he entered the shops of The Bigelow Co., manufacturers of fire- and water-tube boilers. He worked in the shops for about two years and in 1883 he was made secretary of the company. Later Mr. Bigelow succeeded his father as president. He was also president of the National Pipe Bending Co. for the last ten years of his life. He was a director in the Merchants and National Savings Banks and in the New Haven Water Co.

Mr. Bigelow was a member of the American Society of Naval Engineers, a member of the executive committee of the Yale Engineering Association, and was after graduation continuously the secretary of his class, 1881 (Sheffield). He was also president of the Yale Press Association.

He became a member of the Society in 1887. He died in New Haven on June 20, 1917.

CHARLES EUGENE WILLEY DOW

Charles E. W. Dow was born in Manchester, N. H., on April 25, 1859. He was educated in the public schools of that city, and commenced his professional work there by the acceptance of a position as draftsman with the Amoskeag Mfg. Co.

He held successively the positions of chief draftsman with the Brown & Sharpe Mfg. Co., Providence, R. I.; mechanical engineer with the Hotchkiss Ordnance Co., also of Providence; agent for the Metallic Drawing Roll Co., Indian Orchard, Mass., and manager of the American Bolt Co., Lowell, Mass.

Mr. Dow was widely known in the textile industry of this country, having been closely associated with these manufacturers in humidification work and air conditioning for about fourteen years.

At the time of his death he was consulting engineer and vice-president of the Elbert Clarke Co., engineers, of Rochester, N. Y.

He was a member of the New England Cotton Manufacturers' Association. He became a member of the Society in 1911. He died on June 16, 1917.

CHARLES FITZGERALD

Charles Fitzgerald was born in Monroe, N. Y., on October 1, 1859. He received his early business training and experience with the Ramapo Car Wheel Co., in whose employ he worked from 1879 to 1882, leaving that firm to accept a position with John Roach & Sons, Chester, Pa.

His next position was with the American Ship Building Co., Philadelphia, where he was the foreman in charge of the erection of marine engines. From 1885 to 1889 he worked with Robert Wetherill & Co. as outside erection engineer. He was next associated with the Citizens Traction Railway Co. as chief engineer, and later as general superintendent of that company and the Consolidated Traction Co., Pittsburgh, Pa. In 1902 he accepted the position of mechanical engineer with the firm of Booth & Flinn, Pittsburgh. In 1906 he became general manager of the Brazilian Dredging Co., Brazil, South America. At the time of his death he was assistant to the president of the Pittsburgh Valve Foundry & Construction Co.

Mr. Fitzgerald became a member of the Society in 1912. He was also a member of the Engineers' Society of Western Pennsylvania. He died on June 2, 1917.

ALBERT FREDERICK GANZ

Albert Frederick Ganz was born in Elberfeld, Germany, April 25, 1872, and came to this country with his parents in 1881. After attending private and public schools he entered the College of the City of New York in 1886, and completed the first year's work in the mechanical course. For the next four years he was employed in the electrical works of Bergmann & Company, New York City, and of the Edison General Electric Company, Schenectady. During this time he attended the Cooper Union Night School. He entered Stevens Institute of Technology as a member of the sophomore class in 1892 and was graduated in 1895 with the degree of Mechanical Engineer. Immediately after graduation he was appointed instructor in applied electricity; two years later he was advanced to the position of assistant professor of applied electricity and physics; and in 1902 he was appointed professor of electrical engineering and head of the department. With the appointment of class deans in 1908, he became dean of the senior class. The period of Professor Ganz's connection with Stevens—1895 to the present—coincided with the phenomenal advance in the theory and practice of electrical engineering, and it is mainly due to his study and efforts toward improvement that the electrical course was kept abreast of the times and that so many graduates of Stevens have been fitted for responsible positions in the electrical field.

Professor Ganz was widely known in the engineering world, having made many commercial and scientific tests and investigations. He had made a special study of methods for mitigating corrosion of underground structures by electrolysis and was a national authority on this subject. He contributed many valuable scientific papers to technical societies and journals.

In Professor Ganz's death his associates and former pupils have lost a friend whose helpfulness could always be depended on. The great care which he took in reaching conclusions, coupled with his unquestioned integrity, commanded universal respect for his judgment in engineering matters. His untiring energy and intense love of his work were an inspiration to all.

Professor Ganz was a fellow of the American Institute of Electrical Engineers and of the American Association for the Advancement of Science, and a member of the following societies: The American Society of Mechanical Engineers, American Gas Institute, American Electrochemical Society, The Society for the Promotion of Engineering Education, Illuminating Engineering Society, American Water Works Association, National Electric Light Association, and past president of the New York Electrical Society. He was also a member of the Hoboken Board of Trade, the Engineers' Club and the German Liederkranz of New York, and of the Tau Beta Pi fraternity.

Professor Ganz became a member of the Society in 1910. He died on July 27, 1917.

CASIMIR VON PHILP

Casimir von Philp was born in Stockholm, Sweden, in 1853. After having finished his preliminary education, he entered the Stockholm Institute of Technology and in due time was graduated therefrom.

His first position was in the office of W. Wennstrom, in Oerebro, Sweden, but he did not remain there long, and after holding several other positions finally engaged in consulting engineering work. He saw, however, that the United States offered a much broader opportunity, and in 1880 came here with his family.

Shortly after his arrival in America he obtained a position with E. D. Leavitt, of Boston, Mass., and while in his employ had complete charge of several important undertakings, among them being the sewage pumping installation in Boston and the large pumping machinery constructed for the Calumet mines.

After several years in Mr. Leavitt's employ, Mr. von Philp obtained the position of chief engineer with the Burden Iron Company, of Troy, N. Y. In 1890 he became the chief engineer of the Bethlehem Steel Co.

After sixteen years Mr. von Philp severed his connection with the Bethlehem Steel Co. in order to devote all his efforts to his inventions in the field of presses. In 1908, however, he returned to the Bethlehem concern as manager of the machine department, a post which he occupied up to the time of his death.

Mr. von Philp was a member of the American Society of Swedish Engineers, American Society of Engineers, and of The Committee of Fifty, organized to erect a memorial to John Ericsson in Washington, D. C. He was actively interested in the work of this committee and was instrumental in obtaining a donation of $500 to the funds of the committee from the Bethlehem Steel Company.

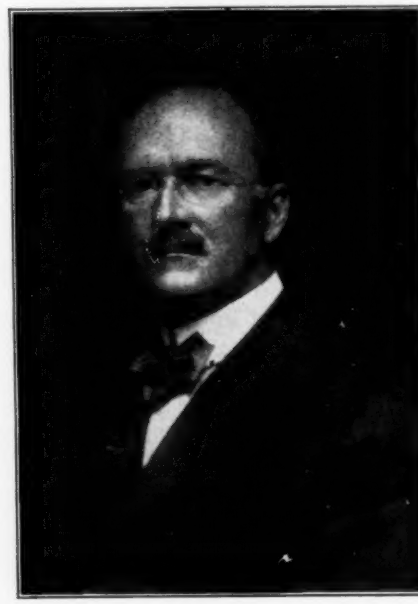
He became a member of the Society in 1890. He died on July 4, 1917.

HENRY SOUTHER

Major Henry Souther, senior officer, aircraft engineering division, aviation section, Signal Corps, U. S. A., and vice-president Henry Souther Engineering Corporation, Hartford, Conn., died August 15 in the post hospital at Fortress Monroe, Va., following an operation. He was born at Boston in 1865 and was graduated in 1887 from the Massachusetts Institute of Technology, where he specialized in mining and metallurgical subjects. After studying abroad the manufacturing methods and processes employed in the German iron and steel industry, he entered in 1888 the employ of the Pennsylvania Steel Co., at Steelton, and was made assistant foreman the following year. He was engineer of tests for the company from 1890 to 1893, resigning to become engineer of tests for the Pope Mfg. Co., a position which he held for six years. At the Pope works he organized the first testing plant ever installed, it is believed, by a consumer of steel for the scientific testing of materials and developed the use of cold-drawn tubing for bicycles and automobiles.

When the Pope organization was dissolved in 1899 he engaged in business as an independent consulting engineer and established a metallurgical and testing laboratory and did consulting work for the automobile industry. He was president and treasurer of the Henry Souther Engineering Corporation from 1899 to 1909 and became president in 1911, but of late years was not very active in the management of that organization. He was vice-president and general manager of the Ferro Machine & Foundry Co., Cleveland, from 1915 to the outbreak of the war. Latterly he had charge of the aircraft development of the army and created a corps for the inspection of aircraft.

He became a member of The American Society of Mechanical Engineers in 1894. He was prominent in the Association of Licensed Automobile Manufacturers, was a founder member of what is now the Society of Automotive Engineers, and had much to do with the development of the iron and steel standards of that body. He was president of that society in



HENRY SOUTHER

1911 and served as chairman of the standards committee for a number of years. In 1915 he was made a life member in recognition of this work.

DANIEL A. WIGHTMAN

Daniel A. Wightman was born in East Greenwich, R. I., on August 7, 1846. He was educated in the schools of East Greenwich, attending for a time the academy there. Having learned the carpenter's trade, he worked at that while taking up the study of drawing at an evening school in Providence, R. I.

About 1870 he took a position as draftsman with the Rhode Island Locomotive Works. He soon became chief draftsman there and for a time was virtually superintendent of the shops. In 1876 he accepted the position of superintendent with the Pittsburgh Locomotive Works and was with them until he retired in 1902, then holding the position of general manager. While at Pittsburgh Mr. Wightman rebuilt the plant and made many improvements in locomotive design, the most important of which was the introduction of power flanging in place of the hand method for heavy boiler sheets. After retiring in 1902 he did some consulting work for the Baltimore & Ohio and Lehigh Valley railroads in connection with locomotive repair shops.

He was a member of the American Railway Master Mechanics' Association. He became a member of the Society in 1884. He died in Warren, R. I., on July 6, 1917.

EMPLOYMENT BULLETIN

THE SECRETARY considers it a special obligation and pleasant duty to make the office of the Society the medium for assisting members to secure positions, by putting them in touch with special opportunities for which their training and experience qualify them, and for helping anyone desiring engineering services. The Society acts only as a clearing house in these matters.

GOVERNMENT REQUESTS

The Society has been asked to make suggestions of men for the following positions with the Government. Further information will be given on request. Non-members of the Society having the qualifications may avail themselves of these notices by enclosing with their reply a personal introduction to the Society.

AERONAUTICAL MECHANICAL ENGINEER. Age, 25 to 40 preferred. Salary, up to $2750. Qualifications: Technical education with degree of M.E. or C. E. or its equivalent and good practical experience with first-class manufacturing concerns. Must be able to handle and direct men. Duties: In Washington, or as district manager of the various branches of the Inspection service; or at one of the various factories where airplanes and engines are being manufactured. 2059 (Serial No. 31).

AERONAUTICAL ENGINEER. Age, 25 to 40 preferred. Salary, up to $3600. Qualifications: Familiarity with complete design of an aeroplane and the ability to carry through new designs in same. Should be able to direct and handle men. Duties: In Washington, or at one of the various airplane factories where airplanes are being made, to act as Senior Inspector or to act as advisory engineer to such inspection force. 2059 (Serial No. 32).

YOUNG ENGINEERS of high grade, experienced in the manufacture of small arms, small-arms ammunition, or similar repetition work, such as the making of typewriters, adding machines and sewing machines, for duty in the Small Arms Division of the Ordnance Department; and also for inspection duty at the various ammunition factories which will supply small arms and small-arms ammunition for the Government. 1108.

MECHANICAL ENGINEER of experience with electrical auxiliary machinery and with hydraulic-electric machinery, of proved ability, to act in consulting capacity in mechanical matters affecting ship design. Salary commensurate with qualifications desired cannot be paid, but nominal salary will be paid and man of high ability who can volunteer balance of services is desired. 1165.

HEATING AND VENTILATING ENGINEER AND DRAFTSMAN.
ELECTRICAL ENGINEER.
MECHANICAL ENGINEER.
Under Civil Service Commission, September 4. Request Form 2118, Treasury Department, Washington. Pending establishment of eligible list temporary appointments will be made, in office of Supervising Architect. Majority of engineers appointed are versed in heating and ventilating work or in electrical work only, but it is planned to include design of entire mechanical equipment of large buildings. 2074.

EDITORIAL ASSISTANT. Position covers the technical review and editing of manuscripts to be published as bulletins of one of the state departments, shorter papers for the trade and scientific journals, preparation of semi-popular articles on the work of the laboratory, news items for the press and assembling of material for monthly and annual reports. Entrance salary, $1500-$2000. 2128.

INSPECTORS AND ASSISTANT INSPECTORS OF ORDNANCE EQUIPMENT. Subclassification of this examination will be for inspectors and assistant inspectors of aluminum and mess equipment. These items comprise such articles as meat cans, aluminum and steel knives, forks, and spoons, plates and similar articles. Their duties will be to supervise the inspection of these items, both in process of manufacture and when ready for delivery. Also, they will have charge of operation of vouchers and other papers by which the contractor receives payment for the articles supplied. These positions are Civil Service appointments and will pay from $1000 to $2000 per annum. Applicants must have completed a course in a college or university of recognized standing and have at least one year's experience in the lines of merchandise they purpose to inspect, or they must have a high-school education or its equivalent and in addition at least four years' experience in these lines of work or in related lines. Applicants should be at least 25 years of age. No person who is liable to call in the first draft quota can be considered for this position. 2117.

MECHANICAL ENGINEERS, ORDNANCE DEPARTMENT, available as Reserve Ordnance Officers, principally with the grade of 1st Lieutenant. Men should be, probably, between 31 and 35 years of age, and graduate engineers who have had experience in machine design. 2072.

MECHANICAL ENGINEER, QUARTERMASTER'S DEPARTMENT, salary $3,000. Qualifications: Training and experience in the design and construction of central heating plants and central power plants, together with general knowledge of mechanical engineering and office administration. Appointments to this position subject to certification from U. S. Civil Service Commission. 2099.

PRODUCTION SECTION, CARRIAGE DIVISION, ORDNANCE DEPARTMENT. Positions: First Lieutenant, Ordnance Officers' Reserve Corps. Salary, $2,000 per year plus $500 (regular army allowance) and traveling expenses. Age, 27 to 40 years. Duties: Positions under both calls will be in Washington or in field work at various factories in the United States. They will be for the duration of the war. Applicants must be physically sound.

Qualifications: Training and several years' experience in machine-shop practice and production. Must be capable of investigating plants to determine capacity for orders and to investigate causes of failures of contractors to make promised deliveries. 2085 (Call No. 36).

Qualifications: Training and experience in purchasing machine tools and equipment, steel castings, forgings, and other raw material and supplies used in machine construction, and general knowledge of them. 2085 (Call No. 37).

For the following positions, Nos. 2118, 2119 and 2120, letters showing qualifications should be sent to the Secretary. Further information cannot be given at this time.

SUPERINTENDENT OF WOOD-WORKING SHOP. To be familiar with the operation of modern planing-mill machinery such as re-saws, rip saws, molders, etc., as required to manufacture wood parts of airplanes and pontoons. Also to be familiar with the construction of life boats or racing shells, or working boats, or airplanes and pontoons. To be of sufficient executive experience to warrant confidence in his ability to build up and control a force of 200 men. 2118.

SUPERINTENDENT OF THE METAL SHOP. To be familiar with general sheet-metal work, including brazing, and welding by the autogenous and spot-welding processes; and with the design of dies for, and operation of, punch presses. To be familiar with general machine-shop and tool-room practice. To have some little experience with manufacturing automatics. To have rudimentary knowledge of the heat treatment of steel. 2119.

ENGINEER OF EXPERIMENTS, OR RESEARCH ENGINEER. To have an engineering education, experience as engineer of tests or research, and an understanding of the value of time. 2120.

POSITIONS AVAILABLE

In forwarding applications, stamps should be enclosed for transmittal to advertisers; applications for non-members should be accompanied by a letter of reference or introduction from a member, such reference letter to be filed with the Society. Copy for notices must be in hand by the 15th of the month.

TOOL DESIGNER who is resourceful and can follow work through to completion. Technical man with practical shop experience. Location Connecticut. 185.

SALES ENGINEERS. It is desirable that applicants be young men between 25 and 30 years of age, preferably M. E. graduates of some approved engineering college, and of good appearance. They will be expected to undergo a period of probation and training in various offices of company for responsible and higher positions in sales work. If a call cannot be made, application may be made by letter in applicant's own handwriting, stating age, education, previous business training, if any, salary desired, etc. Location New York. 205.

STRICTLY HIGH-CLASS MAN who can conduct classes and give lectures covering automobile subjects for a large public institution

of the Middle Northwest. Must be a technical graduate with practical experience and not afraid of work. 421.

ELECTRICAL ENGINEER possessing extensive experience with electrolytic plants for producing oxygen and hydrogen, wanted by New York concern. 811.

MACHINERY DESIGNER in turbine department of large electric company. Location Massachusetts. 894.

MASTER MECHANIC for lead-smelting plant operating blast furnaces and concentrating mills. Must be man of strong personality, capable of handling varied classes of mechanics. Give full details of education and experience. Location Utah. 906.

TECHNICAL ENGINEER with experience in steam engineering to act as assistant operating engineer in large industrial plant located near Chicago. State age, experience and salary expected. 938.

SALESMEN on machine tools to represent large New York exporting corporation in China, Australia and South Africa. 964.

DESIGNERS. Men experienced in steam-engine and turbine work preferred. 967.

DRAFTSMAN familiar with power-house work, installation of equipment, piping, etc., and competent to work out different problems involved from general outline without need of more or less constant supervision. Salary $25 to $28 per week. Location New York. 969.

DRAFTSMEN AND DESIGNERS. Experienced men with some knowledge of valves and fittings; good future with large concern. State experience in full, salary expected and references. Confidential. 1002.

DRAFTSMAN for patent-office drawings. Salary $25 to $35. Location New York. 1022.

YOUNG ORGANIZING ENGINEERS for intensive management work, in general manager's office of one of the large units of the rubber industry. Opportunity decidedly promising. State initial salary expected, age, experience, qualifications, etc. Please give full, character-indicating letter. Location Middle West. 1047.

MECHANICAL LABORATORY ASSISTANT for technical school in Greater New York. Recent mechanical engineering graduate with one or more years of practical work since graduation. Single man about twenty-five years of age preferred. Position offers exceptional opportunity for advancement. State age, education, experience, present employment and references. Enclose photograph with application. Salary $1200. 1060.

ELECTRICAL TESTER wanted immediately by Chicago blower manufacturer; to work as draftsman 20 per cent of time. Permanent position, with opportunity for promotion to salesman, designer or foreman. Salary $18 for first 20 weeks. Experience unnecessary. Describe education and physical condition. 1075.

DRAFTSMAN. Young engineer, preferably technical graduate, with about a year's practical experience; who could work into a good position. Salary $25 to start. Location New York. 1080.

DRAFTSMAN AND ESTIMATOR for work of varied character with large concern; good opportunity for advancement. Location New Jersey. 1104.

MECHANICAL-ENGINEERING DEPARTMENT of a Middle West state college desires applications from men suitable for the position of foreman in machine shop. The successful applicant must have had several years' actual machine-shop work and be familiar with methods of mass production and scientific management. College training desirable but not absolutely necessary. Should have had experience as foreman or assistant foreman in some successful shop, and preferably some teaching experience, although this is not absolutely necessary. Prefer a man not over 35 to 40 years of age. 1112.

DRAFTSMEN experienced in ordnance work, particularly small arms and machine guns; or experienced in complicated automatic machinery. Location Ohio. 1131.

COMBUSTION ENGINEER. Duties primarily those of efficiency work in the burning of fuel and generation of power, also in the use of power in the various departments of plant. Power plant is of 4000 hp. capacity, with extensive distributing system for air, steam and electricity. Excellent opening for a man interested in steam power-plant work. State fully qualifications, training and experience. Location New Jersey. 1133.

GRADUATE MECHANICAL ENGINEER with knowledge of theory of centrifugal machinery—preferably fans, pumps and compressors—and also thoroughly familiar with their design and methods of testing. Apply by letter. Location New York. 1140.

COMPETENT MAN, about 35 years old, to take hold of maintenance and machine repairs and general shop economies. Prefer one with a technical education and enough shop experience to understand the operation of all machine tools, and who has a full appreciation of the value of time on an operation without going into any efficiency work. Opportunity for advancement and eventually an executive position. 1166.

MECHANICAL ENGINEER. Technical graduate, several years' experience along general and mechanical lines. One conversant with industrial machine design preferred. Permanent position with large corporation. State age, college, previous experience and salary desired. Location Cleveland. 2023.

MECHANICAL DRAFTSMAN. Young college graduate preferred. General industrial-mechanical engineering work. Permanent position with large corporation. State age, college, experience if any, and salary desired. Location Cleveland. 2024.

INSTRUCTOR IN MECHANICS and strength of materials wanted by an eastern engineering school. Must have had the usual technical training in experimental laboratory work, so that he can also assist in hydraulic and steam laboratories. Good opening for the right man. State additional training and experience if any. Salary will depend on the amount of work that can be carried. 2025.

ASSISTANT PROFESSOR in sanitary engineering. Location near New York City. 2026.

AUTO REPAIR MAN familiar with Hurlbut type of truck. One-year contract. Prefer a single man. Salary $175. Location Chile, near Valparaiso. Expenses down and back. 2092.

ESTIMATOR for New York concern engaged as engineers and contractors for power plants, ventilation, steam and hot-water heating. 2103.

YOUNG MAN between the ages of 25 and 28 who is not drafted and who is interested in manufacturing work. Position will give him full control of the cost work. Salary to start, $100 per month, and depends upon the man. Applicant need not be experienced in the same line, but should have some knowledge of the line. Location New Jersey. 2109.

ASSISTANT YOUNG ENGINEER for office of consulting engineer, to assist in development of patents and inventions. Location New York. 2110.

SUPERINTENDENT for firm engaged in the japanning and enameling of automobiles. Man of executive ability and experience in lines that would fit him for taking charge of shop. Location Long Island City. 2111.

SEVERAL GOOD DRAFTSMEN who have had experience in designing machine work, in particular stoker work. 2114.

EXPERT TOOL- AND FIXTURE-DESIGNING DRAFTSMAN for line of safety valves, steam gages and similar equipment. Applicant must have sufficient education and experience to enable him to take charge of the drafting department, within a reasonable time, as chief draftsman. Location New York. 2115.

WORKS ENGINEER. Must have thorough knowledge of tool design for automatic machines and ability to plan and demonstrate operations. Duties include general supervision of tool design, tool making machine repair and plant maintenance. Salary to start $3000. Apply by letter. Location Ohio. 2116.

ASSISTANT CHEMICAL SUPERINTENDENT for plant involving a wide field, with over 1200 employees, near New York. Man must have ability to handle men. 2028.

DRAFTSMAN familiar with water-wheel equipment. Unusual opportunity in a Central Massachusetts concern. Technical graduate preferred. 2042.

JUNIOR DRAFTSMAN who can do detail work from sketches or personal instructions. Salary $15 per week. 2043.

MECHANICAL ENGINEER to take charge of engineering department. Must be thoroughly familiar with the design and operation of pulp- and paper-mill equipment. Should be competent to design buildings. A sound working knowledge of steam and electrical power-

plant design and operation is required. Good opening for a capable, energetic man. Location Hammermill Paper Co., Erie, Pa. 2044.

JUNIOR DRAFTSMAN with experience in heavy motors. Salary \$125-175. Location Michigan. 2047.

DRAFTSMAN on electrical machinery for power plant layout work. Salary \$150-160. 2048.

ASSISTANT CONSTRUCTION SUPERINTENDENT. Must be accustomed to handle men, lay out work, to carefully watch all details, etc., and be a good organizer. Main requisites are in connection with mechanical equipment of buildings already erected, i. e., piping, tanks, shafting, timber details, etc. Blueprints will not always show details and considerable knowledge is essential in order to carry on the field work without delay. Salary \$175 to start, advancement according to ability. Give full information by mail as to age, nationality, married or single, liability to draft, references, when could report for work, etc. 2049.

INSTRUCTORS for (1) Applied Science Laboratory and in (2) Mechanics and Elementary Electricity wanted by a technical school in Brooklyn. Salary first year \$1200 to \$1500, according to individual. Preference given to men with mechanical or electrical engineering training and practical and teaching experience. Apply by letter only, giving full personal and experience data and recent photograph if possible. 2050.

INSTRUCTORS. Men of good personality, capable of commanding the respect and attention of the students, most of whom are college-trained men, to train U. S. Army aviators, eight weeks' course. Should be capable of directing the assembling, disassembling and operation of aeronautical motors. Prefer to have college graduates who have had one or more years of practical experience and training in either aeronautical works or on engines in a motor-car works. Salary \$100 to \$125 per month, or more, according to experience and teaching ability. Willing to take a 1917 graduate in mechanical engineering who has specialized somewhat in gas engines, in which case would like to send him for a month of special training to an aeronautical factory and pay him \$85 a month to start. 2051.

MECHANICAL AND ELECTRICAL ENGINEERS. One wanted of each. Preferably married men without children. Positions at sulphur refining factories in France. 2052.

MECHANICAL ENGINEER, age about 35, to travel in Dutch East Indies. Must have thorough knowledge of machinery, steel products and kindred lines of territory named. Export knowledge desirable but not essential. State age, experience and salary expected, also when at liberty. 2054.

YOUNG MECHANICAL ENGINEER who is industrious and capable and has had fuel-economy tests and power-plant testing, and practical experience in the construction and testing of modern Westinghouse steam turbines. Possibilities of advancement for right man. Location New Jersey. 2055.

YOUNG TECHNICAL GRADUATE in production department; one who has had some experience in manufacturing operations and understands machine tools. Position will pay from \$75 to \$100 per month at the beginning and future will depend upon ability. Must be energetic and not afraid of work and capable of developing executive ability. 2057.

DRAFTSMAN on a.c. or d.c. motor design. Salary about \$40 per week. 2058.

RAPID DETAIL DRAFTSMAN AND DESIGNERS on hydraulic turbines, electric furnaces, gas producers, heavy machinery for steel-plant and coke-oven equipment, coal and ore-handling equipment, and complicated structural details. Location Cleveland. 2061.

SALES ENGINEER for Cleveland territory to handle power-plant equipment. Technical graduate preferred with power-plant and sales experience. 2062.

DESIGNER for tools and rapid-production devices wanted by engineering department of a munition factory. 2066.

DRAFTSMEN on mechanical-stoker work. Men familiar with boiler-room layouts, building construction or heavy-machine design acceptable. Salaries up to \$30 per week to start, depending upon ability and experience. Permanent positions. Also draftsmen experienced in auxiliary marine machinery, hoisting engines, hoisting-engine design in connection with this class of machines, engine designers. Salaries up to \$30 per week. Location Philadelphia. 2069.

MECHANICAL ENGINEER who has had several years' experience in the design, construction and erection of machinery, structural work, piping, etc., and preferably as many months' surveying experience, for permanent position among congenial associates. Location New York City, but must be willing to go out of town whenever required. Salary \$225 per month to start. 2070.

TWO TECHNICAL GRADUATES approximately 30 to 38 years of age with experience of sufficient breadth so that they would be posted on problems of manufacture in more than one line. Men who have been steadied by experience, yet ambitious to push ahead and interested in the various problems of manufacture and construction. Location Massachusetts. 2071.

CHIEF DRAFTSMAN. Location Connecticut. 2076.

INSPECTOR competent to handle structural material, for firm of consulting, construction and management engineers. Location Connecticut. 2078.

ASSISTANT SUPERINTENDENT for Chicago tool manufacturer. Start at \$150 per month with increase to \$200. Describe education and physical condition. State number of months in previous positions, exact nature of duties and number of hours per month on each duty. 20,9.

DRAFTSMAN on machine tools. Young man wanted who has had considerable experience in designing machine tools, more especially grinders. Salary \$25 at least, depending upon ability. Location Boston. 2083.

EXPERIENCED TIME-STUDY MAN, familiar with the production of small interchangeable parts, for manufacturing plant in Philadelphia. Position will lead to one of responsibility. 2084.

MECHANICAL ENGINEERS experienced in jigs, dies, gages and fixture work; also in mass production of small articles where drawing and other press work has been the principal occupation. Location New York. 2086.

PRODUCTION PLANNING MAN. One with considerable experience in such work and who is ambitious and capable of getting results. Work will consist of planning the production of ball bearings through the entire shop, routing of the material, etc. Prefer a man not subject to military draft and upon whom considerable authority can be placed. Location Connecticut. 2088.

EFFICIENCY TIME-STUDY MAN who has had some experience along these lines, and, if possible, is acquainted with the manufacture of small parts in automatic machinery and grinding machinery. Location Connecticut. 2089.

EMPLOYMENT DEPARTMENT HEAD. Man wanted to take charge who has had some experience and who understands all the different phases of hiring and keeping help. Location Connecticut. 2090.

PRODUCTION MANAGER for factories located at various places, but with headquarters at New York office. Man between 35 and 40. Salary depends entirely upon man. Write asking for appointment, giving brief record of education and experience. 2091.

INSTRUCTORS in steam-engineering laboratory in training government recruits. \$30 a week, hours 9-11 a. m.—1-3:30 p. m. 2093.

INSTRUCTORS in machine design, with some laboratory work. Location Brooklyn, N. Y. 2094.

ASSISTANT IN STEAM LABORATORY. Salary about \$1,200. Previous teaching experience not necessary. Location Brooklyn N. Y. 2095.

TECHNICAL GRADUATE wanted as instructor in mechanical engineering, tracing, machine design, gas engines and machine shops for southern university. In application state age, education, experience, references and salary desired. 2098.

AUTOMOBILE ENGINEER capable of designing pleasure cars and motor trucks. Experience with Russian requirements desired. Must be good correspondent. Middle-aged man preferred. In first letter state age, education, experience in detail, salary expected, also when at liberty. 2104.

A LARGE GROWING PAPER MANUFACTURING CORPORATION can offer excellent opportunities for interesting and effective work to two young college graduates with tact, initiative, ability and common sense. Non-graduates with two or more years of manufacturing experience will be considered; men wanted who can develop and who have the vision to see and grasp an opportunity. Fair living salary at start. Give complete information. Men will not be engaged until the right ones are found.

EMPLOYMENT MANAGER in plant employing 600 men in the Pittsburgh district. Exceptional opportunity for experienced men. 2122.

PRODUCTION MANAGER in organization operating under a progressive system of management; under the production manager come all questions of planning, scheduling and routing. Man at least 30 years of age who has had a technical training and some years' experience along modern methods of management, and whose personality will enable him to easily control quite a large force of people. Position offers splendid opportunities and pays such salary as will attract a high type of man. Location Middle West. 2123.

DRAFTSMAN. Weekly salary of $20. Apply by letter to Employment Department Maxim Munitions Corporation. Location Watertown, N. Y. 2124.

MAN to take charge of a stationary engineering department, and who has had actual operating experience in addition to a technical training. Opening should be desirable for type of man interested in educational work. Prompt action necessary, because decision will be made in a short time. 2126.

YOUNG SALESMAN in the Boston or Philadelphia districts. Guarantee income and extended commission on sales. Applicant should have an education, good appearance, some advertising or artistic ability preferred. 2127.

STRUCTURAL STEEL DRAFTSMAN experienced in powdered coal plants, industrial plants, power houses, layouts, etc. 1011.

ASSISTANT SUPERINTENDENT for maintenance and construction work in chemical factory. Technical graduate desired. Location St. Louis. Salary $1,500. 1149.

MEN AVAILABLE

Only members of the Society are listed in the published notices in this section. Copy for notices should be in hand by the 15th of the month, and the form of the notice should be such that the initial words indicate the classification. Notices are not repeated in consecutive issues.

PRODUCTION SUPERINTENDENT. American, age 36, married. Twenty years' practical experience in interchangeable parts manufacture, such as locomotives, road rollers, traction engines, conveyor machinery, rock crushers, marine engines, and munitions. Has had wide experience as sales engineer and has successfully held positions as machine shop foreman, general foreman, superintendent. Desires position with Eastern firm, preferably Philadelphia or vicinity. Best of references. I-297.

CONSTRUCTION SUPERINTENDENT. Japanese, aged 42. Fourteen years' practical experience in mechanical and electrical installation work as foreman, inspector of railroad cars and electrical building constructor. At present employed in one of the largest traction companies as power-plant and sub-station designer. I-298.

SUPERINTENDENT. General foreman, who has had seventeen years' experience in mechanical and executive positions in interchangeable manufacturing, desires position. I-299.

MECHANICAL ENGINEER broadly experienced in design and management of power plants, factory maintenance and development of methods and processes, desires position where such experience along with executive ability and chemical training will be of value. At present employed. I-300.

CHIEF DRAFTSMAN OR ASSISTANT ENGINEER, now chief draftsman of a staff of twelve, totaling a monthly payroll of over $2000, desires change of location. Specialty, large industrial plants, as mining and smelting, covering all branches of engineering. Salary $250 a month. Age 36, American born, single. Associate-member A.S.M.E. I-301.

WORKS MANAGER OR CHIEF ENGINEER. Technical graduate, M.E., experienced in superintendence, management, and in shop planning and intensive production of duplicate parts. Salary $3500-$4000, depending upon nature of work. Prefers location near New York or Philadelphia, but will consider any good proposition located in the United States. I-302.

CHIEF ENGINEER AND RESEARCH EXPERT with 16 years' practical training in oil and gas-engine development work. Broad experience in the fine points of both the technical and business side of engineering, with special aptitude for research work and the perfection of new ideas. Thoroughly competent to handle men and to take charge of the development, design and supervision of construction of either marine or stationary internal-combustion engines. At present employed. Best of references. I-303.

MECHANICAL ENGINEER. M. I. T. graduate, age 23, married. Desires a position with a future, where work and responsibility will count. Mechanical and electrical drafting-room experience. At present employed. Location in the East preferred. I-304.

ENGINEERING EXECUTIVE. Technical graduate, age 29, married. Seven years' experience in designing, manufacturing and industrial plant construction. Wants responsible position. At present employed as mechanical engineer for eastern steel foundry. I-305.

STEAM AND COMBUSTION ENGINEER. Technical graduate, age 34, married. Nine years' practical experience with large concerns, including executive experience and the handling of men. Desires change of location. I-306.

ASSISTANT TO EXECUTIVE OR EXPERIMENTAL ENGINEER. Stevens M.E. graduate, age 28, married, finishing present engagement, returns East early in September. Three years' successful experience in executive and experimental work in natural gas, and two years' in power-plant operation. Possesses energy, initiative, self-confidence. Desires position with large industrial or engineering concern. Initial salary not a primary consideration, but position must be permanent and offer a future. I-307.

ASSISTANT SUPERINTENDENT OR CHIEF DRAFTSMAN, age 28, experienced on tools, jigs and fixtures for motors or munitions, wishes to engage permanently with an established firm in this business. Ability has been proved. Salary $2500. Location in the East preferred but not essential. I-308.

MANUFACTURING EXECUTIVE. M. E. Lehigh, age 30, wants to connect with a live organization producing mechanical material. Eight years' executive and practical experience in engineering and efficiency methods, tools, machinery, equipment and labor-saving methods. Specialty, quantity production of interchangeable parts. I-309.

MECHANICAL AND ELECTRICAL ENGINEER. Technical graduate, age 28, two years with engineering department of manufacturer of gas producers, internal-combustion engines and steam pumps; two years with manufacturer of electrical machinery. At present assistant gas and electric inspector in a large city. Also familiar with storage batteries and power-plant practice. I-310.

RECENT M. I. T. GRADUATE desires position involving efficiency, planning or time-study work I-311.

SUPERINTENDENT OR WORKS MANAGER at present employed in that capacity wishes to make a change. Fifteen years' experience in the manufacture of medium-weight interchangeable parts in large quantities. Under favorable conditions would consider making an investment as a guarantee of good faith. I-312.

MECHANICAL ENGINEER AND PRODUCTION EXECUTIVE. Age 39. Practical experience as toolmaker, designer, foreman, supervisor of engineering, tool and experimental departments. Experienced in the manufacture of small and medium interchangeable parts, and knows how to handle men to get coöperation. At present employed but seeks larger field. Location preferred, New York City or vicinity. I-313

EXECUTIVE ENGINEER. M. E. Lehigh, age 43, with good experience along lines involving design, operation, construction, purchasing, management, etc. Several years in responsible charge of the construction of power and industrial plants. Wishes a position of responsibility connected with the commercial rather than the strictly technical side of engineering, as manager, assistant manager, superintendent, sales engineer, manufacturer's agent, etc. At present employed. Salary $3000-3600. I-314

WORKS MANAGER or General Superintendent, age 36, desires connection with large plant making any product from automobiles to clocks. Broad-gage, fully trained executive, experienced in plant layouts, best shop practices, management-control methods, systems and man training. Successful in all jobs successively through production, design and control divisions. A man with vision equal to the possibilities of a business and accustomed to make plans become facts. Full details on request. I-315

MECHANICAL AND EFFICIENCY ENGINEER desires responsible position, any location. Technical education, M. E. and C. E., and 12 years' general engineering experience, including power-plant construction and operation, appraisal work, railroad and highway construction, general machine-shop work, installation, design and construction of heaters and general power-plant efficiency work. Good executive and well known as writer of technical subjects. I-316

CHIEF DRAFTSMAN with broad experience and a successful record desires position with a growing concern where his initiative and industry will lead to advancement. I-317.

ENGINEERING SURVEY

A Review of Engineering Progress and Attainment in Mechanical Engineering and Related Fields, Including a Digest of Current Technical Periodicals and a Selected List of Engineering Articles

Industrial Research in the United States

THE Secretary of the Department of Scientific and Industrial Research (England), issued the first of a series of papers projected by the Advisory Council, and bearing on industrial research. It contains a fully illustrated report of Mr. A. P. M. Fleming on Industrial Research in the United States of America, based on a visit to America last year. The report is divided into sixteen sections, is preceded by a short introduction, and has a good index. The author deals with every kind of industrial research as undertaken by (1) manufacturing corporations; (2) associations of manufacturers; (3) universities and colleges; (4) national institutions; (5) commercial laboratories; and (6) scientific societies. He next discusses the questions as regards (1) endowments for scientific research; (2) the coördination of research in the United States; (3) the selection and training of research men; (4) the fundamental consideration in industrial research; and (5) the organization of British industrial research. All these are fundamental questions which the author's experiences have raised in his own mind or which his readers will be likely to ask. To some of them he suggests answers which cannot fail to stimulate thought and discussion. Industry is the basis of national prosperity, and no stone should be left unturned to facilitate its progress. The instances adduced by the author show that in this respect research is of the utmost importance. The nation is entering upon a new phase in industrial and economic life, and its development will be governed largely by the extent to which new scientific knowledge is obtained and is turned to the benefit of all concerned. (*The Foundry Trade Journal*, vol. 19, no. 187, July 1917, p. 358)

Research as a Profession

Address delivered by Dr. P. G. Nutting before the joint meeting of the Worcester Polytechnic Institute and Engineering Societies on May 18, 1917. The author is engineer in charge of the Research Department of the Westinghouse Electrical and Manufacturing Company at Pittsburgh, Pa.

The most interesting part of the address is that referring to industrial-research organization.

It is the opinion of the speaker that industrial research is preëminently fitted to be carried on by teamwork. He believes that this system is much more efficient than the elimination cell system, where each leading man has a room, or suite of rooms, to himself and keeps his work to himself. In the ideal organization two or three men work together on the same large problem, or group of problems, the aim being to have a good theoretical man and a good experimentalist working together as much as possible, or even a physicist and a chemist in some cases.

The characteristic of the teamwork plan is the conference system. The five or six men most interested in the problem meet for an hour each week to discuss it in its various aspects, to plan new work and to consider various applications of the results obtained. The ideal conference is composed of not less than four, or not more than eight men, and includes an efficient stenographer. To one experienced in such teamwork the results of getting together are simply amazing. A good suggestion is no sooner made than capped by a better one, and the saving in time and effort is almost incalculable.

The conference system aids in putting useful results before the other wing of the Research Division, and before the Patent Department. In the Westinghouse Company, at each of the conferences, were present representatives of the other wing of the Research Division charged with taking up any results immediately applicable; there is also present a member of the Legal Department, who takes care of any ideas worth obtaining. This plan of conference relieves the scientific men from responsibility for calling the attention of the works, or of the Patent Department, to useful obtainable results. (*Journal of the Worcester Polytechnic Institute*, vol. 20, no. 5, July 1917, pp. 312-322.)

French National Laboratories for Scientific Research

The French Academy of Sciences appointed in 1916 a special commission to study the question of the need of national laboratories in France. After reviewing what private initiative has done in France and what the government and private enterprise have accomplished in other countries, notably in Great Britain, the United States and Germany, the commission concludes that there is an urgent need in France for the establishment of a national laboratory for scientific research. Such an institution could be placed under the control of the French Academy of Sciences in the same way as the National Physical Laboratory in London is placed under that of the Royal Society.

After hearing the report, the Academy of Sciences has passed a resolution to the effect that the establishment of a National Laboratory for Physical Science and Mechanics is highly desirable, and that it should be specially entrusted with the work of scientific research for the purpose of promoting industry. The resolution contains some hints as to the status, organization and administration of such a laboratory, further details of which are elaborated in the commissioner's report. As regards financial support for the new institution, the report states that in France it would be useless to wait for the large industrial firms to combine and take the initiative, as they did in Great Britain, and to try to start the laboratory without a Government grant. To insure a successful start for the institution, about $100,000 would be required, apportioned among the central institution and its branches. (*The Iron Age*, vol. 100, no. 6, August 9, 1917, p. 311)

The New Jersey Zinc Company's Franklin Laboratory

The Franklin Laboratory was designed mainly for the analysis of products from the two concentrate mills in its

neighborhood, such as determinations of zinc, iron, manganese, etc., in the ores. Within the last five years, however, it has been found advisable to examine most of the supplies of the mills. and therefore additional space and equipment was allotted for the examination of such substances as oils, greases, soaps, alloys, fuels, paints, explosives, and water.

As the greater part of the determinations carried on are volumetric, good light is a very important factor, and, with this in view the interior walls of the building were constructed of white-enameled tiles laid in Keene cement. This also gives a clean and attractive appearance to the room. As the zinc titration requires a constant light, which is not available, especially in winter, two artificial-daylight lamps were installed and proved to be fully satisfactory.

In the old laboratory great difficulty was experienced in keeping the wooden floor in good condition. Therefore in the new building the wood was treated with aniline black; it is now in excellent condition despite the fact that in many places it has been occasionally subjected to the action of concentrated acids. (D. Jenkins, in *Bulletin of the American Institute of Mining Engineers*, August 1917, pp. 1181-1185, 5 figs.)

A New Tool Steel

British papers contain an announcement, on behalf of Darwin & Milner, of Sheffield, of the discovery of a tool steel stated to be equal in durability and hardness to high-speed steel, yet of which tungsten is not a component.

The new steel is called cobalt-crom, and is based on a discovery that by adding cobalt to chromium carbon steel the latter is converted into a steel which has red-cutting hardness.

Tungsten high-speed steel has not been used to any large extent for milling cutters, taps, reamers, etc., and Darwin & Milner estimate that at least 90 per cent of this latter type of tools are still being manufactured from carbon steel, which is probably mainly due to the difficulty which the toolmaker experiences in hardening such tools. Tungsten high-speed steel requires hardening at from 1250 to 1350 deg. cent., if the best results are desired. To try to obtain this heat for milling purposes is very risky, and to harden at a lower heat gives less satisfactory results.

It has been found, on the other hand, that the maximum heat necessary for the hardening of the new steel is only 1000 deg. cent. It is stated that hardening is satisfactory nearly always when the tool is allowed to cool naturally in air free from drafts and currents, and it is claimed to be possible with the new steel to get absolutely the same standard of hardness throughout.

It is also stated that the cutting efficiency of the new steel is quite equal, even in the form of castings, to that of tools made from forged or rolled bar, in which high-speed steel is supplied commercially, and, as the material in the molten state is much more liquid than high-speed steel, it lends itself to all forms of tool-casting.

As stated in *The Iron Age* (August 16, 1917, page 365), a convention of representatives of the iron and steel industry of Germany has been recently held at Düsseldorf at the instance of the Association of German Steel Makers. It was urged that it was necessary to extend the system of metallurgical research in order to be equipped in every respect for the inevitable economic contest after the war. It was decided to form an institute for undertaking iron and steel research in association with the Kaiser Wilhelm Company, and to raise the necessary funds almost entirely in the iron and steel trades.

Notes from the Engineering Colleges

Equipment of Laboratories—Investigations in Progress—Changes in Curricula

BELOW is a continuation of the review of professional work being undertaken at the engineering colleges. The articles contain information regarding (1) characteristics of laboratory equipment, (2) tests or researches under way or in prospect, (3) important changes in curricula.

The articles are concluded this month.

NORTHWESTERN UNIVERSITY, COLLEGE OF ENGINEERING

Equipment: Electrical Laboratory. The apparatus is provided with special features to make it effective for a general laboratory study in connection with a five-year curriculum leading to the degree of Bachelor of Science at the end of four years and to the degree of Electrical Engineer at the end of five years. Class and laboratory instruction are closely correlated in setting forth and making concrete the fundamental scientific principles underlying the theory, the operation and the design of the electrical apparatus which form the basis of electrical engineering.

Laboratory of Applied Mechanics. This laboratory work is taught directly in connection with the theoretical study of strength of materials. The present equipment includes a 20,000-lb. universal testing machine; a 50,000-in-lb. torsional machine; a 5000-lb. end-load bending machine; a 200,000-lb. compressive-testing machine; an Upton-Lewis toughness-testing machine; a Smith endurance-testing machine; a Fairbanks cement-testing machine, and other apparatus.

Shop Laboratory. The equipment is adapted to instruction in an understanding of shop processes as distinguished from the acquirement of manual skill. The machines are individually motor-driven.

Hydraulic Laboratory. The equipment includes tanks, a centrifugal pump, a Pelton wheel, a hydraulic ram, and other apparatus for the study of small quantities of water flowing through weirs, orifices, nozzles and pipes.

Engine Laboratory. The equipment includes a Corliss engine, a Ball engine equipped with both a throttling governor and an automatic cut-off governor, a Kerr turbo-generator set, a Foster superheater, a steam-flow meter, a Wheeler condenser, and a Foos gas engine equipped for use with various fuels and equipped with hit-and-miss governor and throttling governor, and all necessary instruments for power-plant testing.

Research: Primary and storage batteries; work upon residual stresses, with particular respect to the persistence of these stresses over a period of two or three years; work on web stresses in an I-beam (preliminary work on a 7-in. I-beam has given encouraging results; a 15-in. 42-lb. I-beam is practically ready for testing); efficiencies of gas engines, particularly with kerosene as fuel.

Curriculum: No change is contemplated. The purpose is to furnish a thorough training for the profession combined with the general training of the man. The fundamental aim of education is steadfastly kept in mind in both the class room and in the laboratory, namely, to communicate knowledge of principles which are of broad application and to discipline the intellect. It is believed that the objects of the class and laboratory work are identical, and to this end emphasis was laid on the selection of apparatus which would illustrate the *why*, the rationale of the phenomena under investigation and the *why* of practice.

THE OHIO STATE UNIVERSITY

Equipment: Usual apparatus for work in strength of materials, hydraulics, friction, lubrication, gas, power and steam engineering. This is one of the six universities chosen to establish a cadet aviation school, which started on May 21, to which 25 men will be sent by the War Department each week, given three weeks of intensive military drill and five weeks of instruction in aviation work, and then sent to the Wright flying field at Dayton for their training in flying.

Research Work: Tests on gas engines, on friction and lubrication, and the flow of fluids through pipes and diaphragms; feed-water regulators, and gas tractors.

UNIVERSITY OF WISCONSIN

Research Work: Thesis research on the cycle of temperature in a gas engine. The method originally contemplated was as follows: A number of extremely delicate thermocouples connected in parallel were to constitute a source of current which was to be recorded by an oscillograph. The couples were to be calibrated by rapid introduction to and withdrawal from an electrically heated tube furnace the known temperature of which approximated that to be measured. After some preliminaries a string galvanometer was substituted for the oscillograph on account of greater sensitiveness. (Unfinished.)

Thesis study of the vibration of automobile motors, a mechanical amplifier being used to obtain record which was on a smoked drum alongside a chronographic time line. So far the mathematical deduction that the principal vibration of a four-cylinder motor was of double periodicity with respect to the rotative speed, has been confirmed.

Experimental Work: A 100-hp. uniflow engine has been under test during the past year, and some additional work has been accomplished in testing the laws of flow of oil of a viscous nature through small orifices, and on the behavior of concrete slabs under varying temperatures and moisture conditions.

SYRACUSE UNIVERSITY

Equipment: The laboratories, mechanical, electrical and hydraulic, are fairly well equipped for research; there is a foundry, woodworking department, forge and machine shop. The chemistry department of the University is exceptionally well equipped for research work.

Research Work: The college has done a limited amount of research work; the mechanical department contemplate making a test on shafting friction next fall.

TUFTS COLLEGE ENGINEERING SCHOOL

Curriculum: A new curriculum was adopted this year for all departments. Its first object is to avoid the differentiation of courses during the first two years, and, in the case of such closely allied courses as mechanical and electrical engineering, or civil and structural engineering, to require a common course for three years. The fourth year will then be used for intensive and specialized work more closely allied to professional work. To enable a more discriminating selection of a specialty during the senior year, we have introduced the fundamental principles of each department in courses to be given during the freshman and sophomore year, and required of all students. The elements of surveying, hydraulics, mechanics, mechanism, heat engineering, electrical engineering and chemical engineering are given during this period. These are taught with a proper consideration for the coördination of theory and practice, and in some cases requiring the practice to precede the theory. Many of these subjects are taught by the heads of the respective departments.

A recent addition to the laboratories is in the Department of Electrical Engineering, which has completed the installation of apparatus for laboratory work in connection with its instruction in telephony. There are two complete central offices consisting of standard types of switchboards, terminal and power apparatus, etc., having a sufficient number of circuits equipped for any demonstration desired. One is a simple magneto office with a single-position switchboard. The other is a common-battery office with a three-position switchboard. The circuits are arranged to provide a toll, local and trunk position. Standard apparatus has been used throughout and recent practice followed in its arrangements so that the students may become familiar with the practical side of telephony as they study its principles.

AGRICULTURAL AND MECHANICAL COLLEGE OF TEXAS

Equipment: Texas is essentially an agricultural state and is undeveloped in engineering. For this reason the chief lines of investigation, research and preparedness are along agricultural lines. The present equipment is ample for materials, dynamic, hydraulic, pneumatic, metallurgical, automotive, electrical, chemical, and other engineering instruction, research and study. A mechanical-engineering building is in course of construction and will enable the college to handle almost any kind of research in mechanical lines.

Curriculum: A few years ago changes were made which put the courses up to the standard courses of the country. Recently, modifications in the curricula were inaugurated to meet the needs of the country in military preparedness. A strong feature of the college is its military work. A Reserve Officers' Training Corps has been established and at the time of writing more than a hundred seniors and undergraduates have gone to the Reserve Officers' Training Camp. A number of seniors have also been sent to the different branches of the Naval service.

PURDUE UNIVERSITY

Faculty: An executive committee of fifteen members has been constituted which takes care of routine business and reports to the general faculty. The latter body retains the legislative power and controls all questions involving new rules. The executive committee meets twice a month and the general faculty once a month on stated days.

Engineering Experiment Station: This has been created for the conduct of research work in engineering. The dean of the engineering schools will be director of the station and will have associated with him the heads of the engineering schools in a board of management. The station will be in a position to extend the same assistance to the manufacturing industries and public utilities of the State as has been afforded the farmers by the agricultural station.

Short special courses will be started to prepare men for special Government service.

Research Work: Effect of flat spots on railroad car wheels; testing of side frames and low temperature effects on steel rails; testing once a month for the past twelve months, of a locomotive to determine the loss of efficiency due to boiler scale; study of the fire-carrying possibilities of locomotive

sparks of known temperature; testing of brake beams; work on carburetors; work on a bituminous gas producer; research on different kinds of pulleys and belt of different tannings; tests on two types of refrigerating cars; establishing a correct method of measuring heat and a proper rate of charge to the consumer using hot water or steam from a central heating station; comparative tests of all the bituminous furnace coals of Indiana with coals from Pennsylvania and Illinois; the possibilities of powdered fuel in stationary boilers.

The University specializes in Railroad Engineering and Gas Engineering.

RENSSELAER POLYTECHNIC INSTITUTE

Equipment: The laboratory is primarily fitted for instruction work. There has been no specialization.

Research: During the past year work on the determination of the coefficient of heat transfer through blocks of commercial insulation has been carried out.

Curriculum: A course in military engineering and instruction will be established next year.

MICHIGAN AGRICULTURAL COLLEGE

Equipment: The laboratories are provided with typical steam engines, gas engines, pumps, electric motors, air compressors and heating apparatus, the ordinary apparatus required for determining the strength of materials, etc.

Research Work: Carburetor behavior, tests on various kinds and makes of gasoline engines, problems involving repetition of stress in materials, and combined stresses in materials, such as combined torsion and bending, experiments on the power required to operate drills at various speeds and feeds.

Curriculum: A course in chemical engineering has been added.

WASHINGTON UNIVERSITY (ST. LOUIS)

Equipment: Laboratories are equipped to do research work on fuels, gas and steam appliances, automobiles, etc., and especially equipped for testing cutting tools.

Research Work: Tests have been made on steam-turbine nozzles, automobiles, and high-speed steel cutting tools, but the work may not be completed owing to the seniors carrying on the work being excused for military duty.

High-Speed Steel Alloys

A patent issued to Radclyffe Furness, of Jenkintown, Pa. (assignor to the Midvale Steel Company), states that if a certain amount of both cobalt and tungsten be added to an ordinary high-speed tool steel, containing tungsten, chromium and vanadium, a substantial increase in cutting efficiency is attained. The amount of uranium is so small that it cannot be said to replace the known high-speed tool-steel additions, its presence even in apparently negligible proportions improving the efficiency of the tools.

	Preferred analysis, per cent	Limiting proportions, per cent
Cobalt	4.5	3.0 to 7.0
Uranium	0.7	0.1 to 2.0
Tungsten	13.5	12.0 to 20.0
Chromium	3.5	2.0 to 6.0
Vanadium	1.5	0.5 to 2.0
Carbon	0.7	0.5 to 0.9

(1,233,862, July 17, 1917.) (*Metallurgical and Chemical Engineering,* vol. 17, no. 4, August 15, 1917, p. 191)

This Month's Abstracts

The latent heat of steam is a subject still attracting the attention of engineers.

In the present issue will be found an abstract of an investigation by Frank B. Aspinall, of interest because it establishes certain novel facts. Among other things the claim is presented that water can be present in steam in some form which is not a mechanical mixture, and further, that steam has a dewpoint like air.

The basic laws for heat of steam are enumerated, and values are offered for the latent heat of steam and heat latent, when absolutely no water is present, as well as for the constant representing pressure multiplied by the volume.

In the section Aeronautics is abstracted an article on measuring stresses in aeroplane wires by means of an instrument called a frequentiometer, which utilizes the phenomena of resonance for this purpose.

In the same section is presented a description of a German aeroplane possessing several features of interest, in particular the location of the radiators on the sides of the fuselage instead of in front.

In a paper before the American Society of Heating and Ventilating Engineers, Arthur K. Ohmes shows by a parallel series of determinations that the value of air flow cannot yet, except in the simplest cases, be determined by the application of the known formulæ and coefficients of resistance.

The influence of high temperature upon the elastic and tensile properties of wrought iron is discussed in detail by Frank A. Epp and E. Olney Jones. They come to the conclusion that for iron intended to be used at high temperatures a different factor of safety should be used than for iron used at low temperatures.

In a report abstracted from *Stahl und Eisen* through a British periodical, are given the results of experiments carried out in Germany with the view of ascertaining the influence of carbon, silicon and phosphorus on the mechanical strength of cast iron.

The practice of a central station of the Toledo Railways and Light Company in the use of combination coal and gas firing, reported in the section Firing and Fuel, indicates that the amount of coal burned per hour with the combination firing is practically the same as the amount burned when coal alone is fired. The efficiency of the boiler, furnace and grate was not materially improved by the use of combined firing, and the cost of evaporating water with the combined firing is 8 per cent higher than with coal alone; but on the other hand, an added evaporative capacity of 31 per cent was obtained with 50 per cent less investment than would be required with coal alone.

The quenching process, and in particular the influence of the surface factor, is discussed by Lawford H. Fry, member of the Am.Soc.M.E., in the abstract in the section Machine Shop. The writer, among other things, makes a careful distinction between the rate of loss of heat by the body subjected to quenching and its rate of loss of temperature, and shows that under certain conditions water-cooled pieces of steel may have the same properties as air-cooled pieces.

The brick-arch tests of the Pennsylvania Railroad, reported in the section Railway Engineering, present a good example of carefully conducted experiments on an interesting and difficult subject. These experiments appear to have established the fact that both the equivalent evaporation and the efficiency of the boiler are noticeably improved by the presence of the arch.

REVIEW OF ENGINEERING PERIODICALS

SUBJECTS OF THIS MONTH'S ABSTRACTS

Aeronautics

New Method for Regulating the Tension of Aeroplane Wires by Means of a Frequentiometer.

Carlo Maurilio Lerici

In regulating the tension of aeroplane wires it is necessary that the distances between the ends of each wire should be constant, that symmetry of construction should be maintained and that the tension itself should not exceed a certain limit determined either practically or by calculation.

Since, however, in the vast majority of cases, this regulation is carried out in a purely empirical manner, it is not unusual that a difference of 30 to 40 per cent between the tensions of symmetrical wires in the same machine occurs, and quite often such differences do not produce any noticeable alteration in the symmetry of the aeroplane while it is at rest.

The process described in the present article is said to have been successfully tested out. It appears to be simple and susceptible of great precision. This method of measuring the tension of wires utilizes the phenomena of vibratory resonance and is analogous to that employed by Captain Largier in his musical tension meter.

The present apparatus is based on the application of the formula

$$T = \frac{4\, l^2 p n_1^2}{g} = K n_1^2$$

where T is the tension of the wire; l the length of the wire; p the weight of the wire per unit of length, n_1 the frequency of vibration and g the acceleration due to gravity, all in metric units. For a given wire, in order to determine the value of T, all that is necessary is to know that of n.

The present apparatus is so designed that n_1 can be measured directly. It is nothing else but a frequentiometer similar to that used for measuring the frequency of alternating currents, but more simple in construction and more convenient to handle.

As shown in Fig. 1, the apparatus consists of a series of steel plates of different lengths rigidly held at one of their extremities. In accordance with the usual formula the dimensions of each plate are in a relation with the natural period of oscillation of the plate expressed by the formula

$$t = \frac{1}{n} = \frac{8L^2}{\pi\, b(1198)^2}\sqrt{\frac{5\,d}{6\,gE}}$$

where L is the length of the plate; b the radius of inertia of its section; g acceleration due to gravity; d density and E modulus of elasticity of the plate.

In accordance with the laws of resonance, when a plate rigidly held at one end is placed into light contact with a vibrating string, it obtains a very noticeable maximum oscillatory movement, provided its natural period of oscillation is

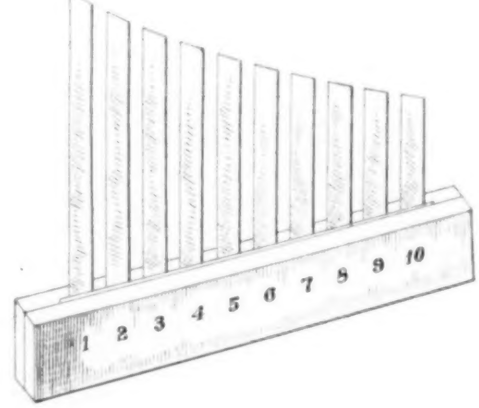


Fig. 1 Frequentiometer for Determining the Tension in Aeroplane Wires

equal to that prevailing at the instant in the wire. It is not even necessary that the plate be in direct contact with the vibrating wire, and it is enough that the support of a series of plates of a frequentiometer be placed in contact with one end of the vibrating wire. In this way there is no difficulty in determining the particular plate of which the natural period of oscillation is nearest to that of the vibrating wire. The proper selection of a set of plates makes it possible to secure indications of a far higher precision than can be obtained by the empirical methods employed in the majority of shops.

With the type of frequentiometer described there is a possibility that both the fundamental vibration and the secondary vibration may appear, if in the set of plates used there are two plates such that the period of one is twice as great as the period of the other. In practice, however, the series of plates employed reproduces only a limited number of vibrations. Furthermore, even should a case of multiple resonance be observed, all that would be necessary would be to consider only the indications of the plate having the least period.

In fact, for regulating the tensions of wires in the fuselage

and landing gear of modern medium-powered machines (100 to 300 hp.), it is enough to have a set of plates of from 20 to 40 oscillations, and actually a dozen plates will give indications sufficiently precise for all practical purposes. With such a set the average error due to the presence of turnbuckles does not exceed five per cent.

The frequentiometer may be so designed as to have a scale in kilograms for each type of wire. If each plate has a marking showing its frequency, a corresponding tension in the wire may be found from a chart giving the interrelations of the frequency, the length of the wire, diameter (or weight per meter) and the tension. Two such charts are given in the original article. (Nouvelle méthode pour le réglage de la tension des haubans des aéroplanes au moyen d'un frequentiomètre, Carlo Maurilio Lerici, *Le Génie Civil*, vol. 71, no. 3, July 21, 1917, pp. 39-41, 5 figs., *d*)

The Albatros D.1 "Chaser" Biplane

Description of the German Albatros "Bu" chaser scout machine.

Although being comparatively heavy and lacking the high speed and other performance qualities possessed by some of the machines of the Allies, it has proved a formidable fighter. The present description is based on a thorough examination of a machine brought down some six months ago on the British front.

The fuselage is of the monocoque type, built up entirely of wood without any wire bracing.

The arrangement of the planes, contrary to the usual German practice, has neither sweep-back nor dihedral, the top plane, in fact, being one complete unit. A somewhat novel feature consists of the method of adjusting the stagger of the top plane from 0 to 12 cm. by moving it along the top of the cabane. This is done in the following manner. In each end of the top horizontal tube of the cabane is formed a slot which receives an eyebolt passing through the main spar of the plane. Each slot has five holes passing horizontally through the tube, one of which, according to the adjustment required, receives the bolt that locks the eyebolt in the cabane. Only one pair of struts on each side of the fuselage separate top and bottom planes, these struts being of streamline steel tubing. The top fittings are slightly different from the lower ones, which are adjustable. The main spars are located well forward, the front ones being some four inches from the leading edge and spaced to fit $7\frac{1}{2}$ in. from the rear one. They are of rectangular section, fabric-bound, and are beveled off from the top at the extremities. The lower plane is attached to an abutment built out from and flushed with the side of the fuselage. The stabilizing plane, semi-elliptical in plan form, is divided into two parts and is exceptionally thick ($5\frac{3}{4}$ in.). It is non-lifting and is mounted in the line of flight without any external bracing. Hinged to the trailing edge of the stabilizing plane is a single elevator balanced by small triangular extensions forward of the outer extremities. The system of supporting the rudder and tailskid is described in detail.

The fuselage is a compromise between the formal standard Albatros system and the true monocoque type. In section it varies from circular at the nose to a horizontal knife edge at the rear and is flat-sided with rounded top and bottom in the center. The method of construction of the fuselage is described in some detail.

The radiators differ from those usually employed. They are of the honeycombed type and are mounted one on each side of the fuselage. Above and at the left of the camshaft is a flat water tank, one end connected to the engine jacket and the other end to the tops of the radiators. The lower orifices of the radiators are connected to the water pump at the rear of the engine. On each side of the engine is mounted a machine gun synchronized for firing through the propeller. (*Flight*, vol. 9, no. 26/444, June 28, 1917, pp. 628-644, illustrated, *d*)

Air Engineering

A Study in Air Measurements and Air Flow, Arthur K. Ohmes, Mem.Am.Soc.M.E.

Data of an interesting investigation bearing on the comparison of test results on one hand, and theoretical results of air movement on the other hand, with special reference to flow of air through small channels under very slight pressure differences.

Among other things, these tests have established that there are now fairly complete means available for engineers in conducting tests on air-flow measurements.

The writer checked the results of tests with such tests as would be theoretically derived by the application of proper formulæ, and found the following situation to exist: As regards the pressure differences necessary to drive a certain amount of air through a channel at an assumed velocity of 10 ft. per sec., he found for the square channel that, whereas the pressure was 0.092 in. of water, the test showed only 0.032 in., or a proportion of 1 to 2.88.

Likewise, in the case of the round channel, the proportion between the test magnitude and the theoretical value was as 1 to 2.5. In other words, the theoretical resistances are greater than the accurate testing results indicate them to be. On the other hand, nearly all coefficients are usually increased by the authors some 15 to 20 per cent for safety reasons.

As regards coefficients of resistance, the data do not appear to be entirely conclusive, but as regards the velocity of air secured under certain pressure differences, it was found that, whereas, according to theory, for a given pressure difference a velocity of 5.95 ft. per sec. would have been obtained with the square channel, and 6.2 ft. per sec. with the round channel, the actual velocities were in each case 10 ft. per sec., or 1.68 and 1.61 times as much as the theoretical values. (These latter neglect the very small frictional losses.)

Altogether, it would seem that tests of this kind cannot as yet be dispensed with, because we have scarcely sufficient coefficients of resistance at our disposal to determine flow of air in any but the most ordinary duct systems, and even this with no scientific accuracy. (*Journal of the American Society of Heating and Ventilating Engineers*, vol. 23, no. 4, July 1917, pp. 577-586, 9 figs., *et*)

Engineering Materials

The Briquetting of Metal Swarf

Third article of a series. The preceding two articles (*Engineering*, June 8 and 15) describe the advantages derived from the application of briquetting to scrap which has to be remelted in ordinary furnaces.

Taking British costs as a basis, it appears that the cost of briquetting in a plant which is kept constantly at work may not amount to more than, say, 25 shillings (say, $6.00) per ton, including allowances for standing charges, such as overhead, depreciation, etc.

As regards machinery, the writer states that there is already

under construction by a British manufacturer a machine which is to have an output of some 6½ tons per hour when dealing with non-ferrous scrap. The question of the size of the machine has an effect on the cost of briquetting per ton, the larger the machine, other things being equal, the less the cost per ton, provided enough material for the machine is available.

The briquets made by the larger non-ferrous machines are ordinarily in the form of a cylinder 6 in. long by 6 in. in diameter. According to a statement made to the writer by a representative of the Southwark Engineering Company, of Philadelphia, Pa., the approximate weight of briquets 6 in. long by 6 in. in diameter is as follows:

From steel turnings, 38-43 lb.
From iron turnings, 35-40 lb.
From copper turnings, 43-49 lb.
From brass turnings, 41-46 lb.
From aluminum turnings, 13-15 lb.

As regards the method of briquetting, a British engineer, who designed the plant mentioned in the earlier part of this abstract, has found, in the first place, that it is much better to use oil as the hydraulic fluid than water. He found that with oil, in addition to avoiding corrosion, the leathers last much longer and the cost of repairs and renewals is considerably decreased. Further, he has found that there is a distinct tendency for the molds to become barrel-shaped, so that if they form an integral part of the mold table, the expense of putting them right is very high. He has, accordingly, made the molds entirely separate from the table, and when they become worn he simply removes them and replaces them by others, this being done at much less cost and much more quickly than repairing molds on the table.

As regards binders, he has found that the employment of a suitable binding material is a most important factor in the production of successful briquets. He himself uses a mixture of linseed oil and resin melted together and mixed with the scrap. The proportions here recommended are about 22½ lb. of oil and 1½ lb. of resin to the ton of scrap. The briquets were made with this binding material and dried for 12 hours in an oven. He also lays great emphasis on the necessity for employing heavy pressures. For the non-ferrous briquets which he is making he puts on a maximum pressure of 180 tons dead load, which means an actual pressure on the scrap of about 21½ tons per sq. in. (*The Engineer*, vol. 123, no. 3208, June 22, 1917, pp. 557-558, 2 figs., *d*)

The Influence of High Temperature Upon the Elastic and Tensile Properties of Wrought Iron, Frank A. Epp and E. Olney Jones

The modern use of iron and steel under stress at temperatures considerably above the usual range makes an investigation in this field of possible commercial and engineering value.

For metals at ordinary temperatures, the use of a proper factor of safety brings the stress for which the piece is designed well within the elastic limit. But, as the results of this test would indicate, at higher temperatures this design factor of safety will have to be modified greatly or the work will have to be designed wholly on the basis of the elastic limit.

As examples of the employment of iron in stressed condition at high temperatures, the writer quotes the following: Temperatures of superheated steam vary now from 450 to 550 deg. fahr., and the strength of tubes, valve stems, etc., as affected by these temperatures, is, indeed, worthy of serious consideration. Other examples of the same condition are encountered in boiler construction, metal rigging above large crucibles or ladles carrying molten metal, etc.

In the present series of tests wrought iron was brought to the desired temperature in an electric furnace (and was, therefore, not affected by the gases of combustion), and then submitted to various physical tests.

The article describes in detail the apparatus used, methods of calibration and conduct of tests. As regards the apparatus, the most interesting piece used was the extensometer rigged up for this purpose. While very simple in construction, it has a least count equal to 0.0002.

A complete summary of all tests is given in the accompanying curves.

From these results it appears that the ultimate tensile strength of wrought-iron bars increases as the temperature increases from 70 deg. fahr., until a maximum is reached between 350 deg. and 550 deg. fahr.

From the temperature of maximum strength the tenacity diminishes rapidly until the highest temperatures covered by these tests are reached.

The greatest gain over the strength of the metal at 70 deg. fahr. was 37.6 per cent. This occurred at 430 deg. fahr., as judged from Fig. 2. The loss at 1000 deg. fahr. over the strength of the metal at 70 deg. fahr. was 53.5 per cent. A continuation of the curve at 1200 deg. fahr. indicates a loss in strength of 75 per cent.

The elastic limit appears to decrease from 70 deg. fahr. to about 270 deg. fahr., showing a maximum decrease of about 13 per cent. From that temperature the elastic limit appears to increase suddenly to about 350 deg. fahr., where it reaches its maximum value of about 10 per cent above the stress at 70 deg. fahr. From here on it gradually drops, and at 1000 deg. fahr. shows a loss of 70 per cent over the elastic limit at 70 deg. fahr.

Owing to a period of rapid yielding without increase of stress, the yield point is well defined at moderate temperatures. This yield point, however, vanishes at about 500 deg. fahr., and the stress-deformation curve assumes a gradual slope from the start to finish.

With reference to elongation under stress, this peculiarity is noticed: that greater rigidity exists under certain stresses

The physical properties of wrought iron are materially affected by high temperature.

The ultimate tensile strength increases as the temperature increases from 70 deg. fahr. until a maximum is reached between 350 deg. and 550 deg. fahr.

Tenacity diminishes rapidly with increase of temperature.

The elastic limit appears to decrease from 70 deg. fahr. to about 270 deg. fahr., showing a maximum decrease of about 13 per cent. From that temperature the elastic limit appears to suddenly increase to about 350 deg. and then gradually drops.

The curve of elongation versus temperature is irregular.

For iron intended to be used at high temperatures a different factor of safety should be adopted than the one for iron used at low temperatures.

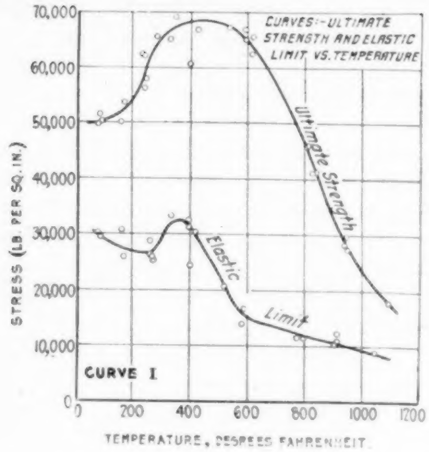


Fig. 2 Curves of Ultimate Strength and Elastic Limit versus Temperature for Wrought Iron

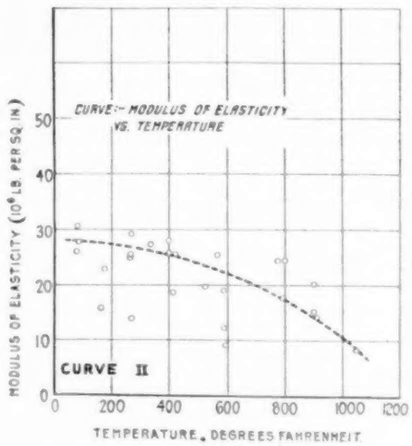


Fig. 3 Curve of Modulus of Elasticity versus Temperature for Wrought Iron

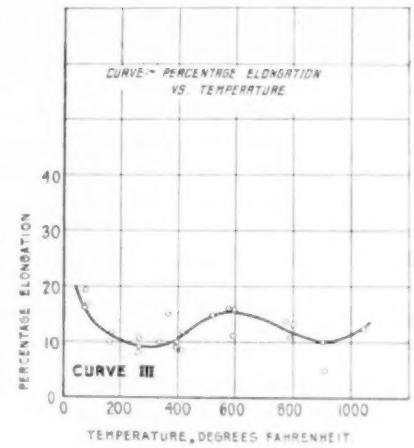


Fig. 4 Curve of Percentage Elongation versus Temperature for Wrought Iron

at intermediate temperatures than at either higher or lower temperatures. Thus it will be noticed in Curve III that at 300 deg. fahr. and 900 deg. fahr, the metal shows only about half the elongation that it shows at 70 deg. fahr. It is surmised that beyond 1000 deg. fahr. the curve gradually rises and the metal exhibits powers of greater ductility as it approaches a workable heat.

Other remarkable features in the elongations are found in bars tested at temperatures varying from 200 deg. to 400 deg. fahr., in which there are displayed alternate periods of rigidity and relaxation under increasing stresses.

It will be readily observed how irregular Curve II is beyond the yield point. Some of the tests taken at this temperature showed even greater irregularity. The repetition of these intervals of rigidity and relaxation is suggestive of some remarkable change taking place within the metal in this zone of temperature, conspicuous in a series of tests possessing many remarkable features.

The contraction of area at the place of rupture varies with the temperature of the bar. It appears that the contraction of area of wrought-iron bars is a great deal less between 200 deg. and 600 deg. fahr. than at 70 deg. fahr., and within this range of temperature there is a tendency to fracture obliquely across the bar.

The results obtained for the modulus of elasticity have very little value, except that they indicate a gradual decrease.

It is shown conclusively that should similar iron be used in work where the design factor of safety was five, and where the temperatures were 900 deg. fahr. or above, the part under consideration would be stressed beyond its elastic limit if the allowable stress was applied. Furthermore, at that temperature the factor of safety on the ultimate strength would be reduced to three. Curve I shows the relation of ultimate strength and elastic limit throughout the complete temperature range.

For tubes, valves, pipe lines, etc., carrying superheated steam, Curve I shows that at 600 deg. fahr. the elastic limit has fallen 50 per cent of its value at ordinary temperature, hence a design factor of safety in superheater construction should be so modified as to give an ample factor on the elastic limit at this temperature. Assuming that the factor of safety is five on the ultimate strength at 70 deg. fahr., this would be equivalent to a factor of three on the elastic limit at the same temperature. Therefore, considering that the metal should never be stressed to more than one-third of its elastic power, at 600 deg. fahr. the factor of safety would have to be ten on the ultimate strength of the metal at 70 deg. fahr.

Reference to Curve III indicates that the metal is very brittle between 150 deg. fahr. and about 1100 deg. fahr. Where this state exists, it is, of course, impractical to work the metal. In other words, it would be better to work the metal cold than at 200 deg. fahr., at which temperature it might fracture without warning. Nine hundred degrees fahrenheit is even a more critical point, for here the ultimate strength and the elastic limit have dropped to less than half their original values.

The conclusions attained are rather startling. The wide fluctuations in the physical properties are not generally realized.

A brief bibliography of the subject is appended. (*Metallurgical and Chemical Engineering*, vol. 17, no. 2, July 15, 1917, pp. 67-71, 6 figs., *eA*)

The Metallurgy of Ferrochromium, Robert J. Anderson

An article of a general nature describing the manufacture of ferrochromium and chromium steel and outlining the use of the latter.

Chromium in steel does not act as a scavenger, nor does it confer soundness on the steel as do silicon and aluminum. But added in small amounts it increases the tensile strength of the steel to some extent without markedly decreasing its ductility. When added in excessive amounts it causes brittleness.

The effect of chromium when added to steel is to raise the normal critical range, thus causing changes to take place at high temperatures and also more slowly. Hence, chromium steels are harder than ordinary steels, because quenching more effectively prevents the transformation of the austenite. When added to iron, chromium does not materially harden the metal. Chromium steels contain from 1 to 4 per cent or more of chromium, and the carbon may range from 0.50 to 2 per cent. (*The Iron Trade Review*, vol. 61, no. 2, July 12, 1917, pp. 75-78, 3 figs., *g*)

Properties and Structure of Nickel Steel, S. W. Parker

Data of experiments made at the testing department of the Bethlehem Steel Company at Steelton, Pa., in order to

determine the best annealing temperatures for two grades of 3.50 per cent nickel steel, commonly used for forgings.

The test bars used were forged down to 1 in. sq. by 6 in. long from two 4 x 4-in. billets of different grades. The writer describes in detail the methods of testing and states that the minimum hardness and tensile strength were obtained by annealing at between 1250 and 1350 deg. fahr., at which temperatures the structure had only started to break up and refine. The property most affected by annealing is the elastic limit. This was increased from 41,000 lb. per sq. in. in the unannealed bar to 50,000 per sq. in. in the bar annealed to 1400 deg. fahr., in which the grain was the finest in the series. This increase in elastic limit by refinement of grain plays an important part in annealing forgings, especially when the specifications require high elastic limits together with good ductility.

The best combination of physical properties in the case of 3.50 per cent nickel steel of 0.22 per cent carbon is obtained by annealing at a temperature ranging between 1400 and 1450 deg. fahr.

A similar series of tests on nickel steel of 0.41 per cent carbon indicated a general similarity in the properties. For this steel the best combination of physical properties is obtained by annealing at between 1350 and 1450 deg. fahr., the minimum temperature being lower than in the case of 0.22 per cent carbon steel. (*The Iron Age*, vol. 100, no. 2, July 12, 1917, pp. 67-69, 18 figs., *e*)

Metallurgy of Cast Iron

Mr. A. Stadeler, in recent issues of *Stahl und Eisen*, reports the results of experiments carried out by F. Wust and his pupils with a view of ascertaining the influence of carbon, silicon and phosphorus on the mechanical strength of cast iron. Various mixtures were prepared of Swedish charcoal pig with Swedish horseshoe iron, the silicon, manganese and phosphorus contents being varied by the addition of ferroalloys. As square or rectangular test bars are liable to develop a white iron at the edges, test bars cast round and turned down were used in the experiments. The quantity and character of the graphite appear principally to determine the mechanical properties, but these are materially influenced also by the pouring and method of cooling. With gray iron containing 1.5 per cent of silicon, small quantities of manganese, up to 0.3 per cent, increase the formation of graphite, but a further increase to 2.5 per cent has no influence. Cast irons high in phosphorus, contrary to existing ideas, may be improved by the presence of 1 per cent of manganese, or more, provided the rest of the ingredients has been fixed properly. With a rise in the proportion of graphite the strength of the iron in tension and bending falls off, as a rule. This is also the case with an increase in the percentage of carbon and silicon, both of which favor the formation of coarse graphite. With increase of phosphorus up to 0.3 per cent, and of manganese up to about 1 per cent, the strength in tension and bending increases. Phosphorus up to 0.3 per cent and also high graphite content enhance the bending strength, while manganese and silicon have the opposite effect. The resistance to specific impact shows the greatest sensitiveness to silicon, manganese and phosphorus. It diminishes rapidly as the phosphorus content rises until this reaches 0.6 per cent, above which the decrease is considerable. This property brings out the superiority of irons low in phosphorus, in respect of resistance to impact, which the tensile and bending tests fail to reveal. Hardness decreases with a rise in graphite content and is increased by a rise in manganese and phosphorus. It does not seem to be affected by the silicon content, but the physical properties of cast iron depend not only on the percentage but also on the character of its graphite content, and an explanation of the difference in the physical properties of test pieces containing the same percentages of carbon can be readily found by an examination of their microstructure. (*Page's Engineering Weekly*, vol. 31, no. 670, July 13, 1917, p. 19, *g*)

Firing and Fuel

Combination Coal and Gas Firing, Alex W. Morgan

Description of the Water Street Station of the Toledo Railways and Light Company, where conditions were such as to make it advisable to use this system of operation.

A large number of boilers of the company are now equipped for combined firing. At first gas alone was burned under six type S 475-hp. Stirling boilers equipped with McKinzie grates. These grates were partly covered with asbestos and a space of 12 in. wide was left uncovered for a secondary air port. The front of this air port was 40 in. from the burner tips and flush with the nose block of the ignition arch. Over this entire grate surface was spread firebrick crushed to the size of an egg, a layer varying in thickness from about 2½ in. at the burner tips to 7 in. at the bridge wall. This cover deflected the flame and prevented it from striking the tubes directly. With this arrangement it was found that the rating was limited and the installation lacked flexibility.

To burn the gas directly above the coal in combination with it, a special tile with a 2.5-in. hole was developed and set so that the gas, when introduced into the firebox, was directed down against the coal. This tile was placed in the ignition arch next to the grate. All primary air was shut off and the gas in the firebox made to depend upon the secondary air coming through the fuel bed for its combustion.

Tests were then made to determine accurately the performances of the boilers thus equipped. The boiler used for these tests is of the Stirling type with a heating surface of 6680 sq. ft. and a superheating surface of 256 sq. ft., designed to deliver steam at 200 lb. per sq. in. pressure and 100 deg. fahr. superheat at rating.

The results obtained indicate that the amount of coal burned per hour with the combination firing was practically the same as the amount burned when coal was fired, and hence the additional rating developed was the result of the introduction of gas in the furnace. This additional rating was 31 per cent over that obtained with coal alone.

The temperature of the flue gases leaving the boiler was 43.4 deg. fahr. higher with the combination than with coal alone. The stack temperature during the tests was considered to be too high, and it was found that better results came from getting a lower stack temperature with the combination than from coal alone.

The efficiency of the boiler, furnace and grate was not materially improved by the use of the combination.

One of the conclusions arrived at is that the cost of evaporating 1000 lb. of water from and at 200 deg. fahr. is 8 per cent higher for the combination fuel than for coal alone, and 21 per cent higher for gas alone than for coal alone (taking the cost of fuel as it was at the time of the tests, November 1916). Nevertheless it was calculated that the added capacity with the combination fuel was obtained at 50 per cent less investment than would have been required with the coal.

Considering the situation from an operating standpoint the company obtained 31 per cent added capacity with an 8 per cent increase in the cost of producing a pound of steam. With the increased cost of coal becoming operative, this increase in cost over the cost of coal to produce a pound of steam would be offset.

The original article gives also a set of curves showing points at which combination coal and gas firing is economical. Another illustration in the original article shows two boiler-meter records of tests, one where coal alone was burned and another where gas and coal were fired in combination. (*Electrical World*, vol. 70, no. 2, July 14, 1917, pp. 52-54, 4 figs., *e*)

The Value of Peat Fuel for the Generation of Steam, John Blizard

Report forming the third and last of a series comprising the investigation undertaken some years ago by the Department of Mines of the Dominion of Canada to determine the value of peat fuel for the production of power. The former reports, entitled Utilization of Peat Fuel for the Production of Power, and Peat, Lignite and Coal, dealt mainly with the production of power through the media of gas producers and internal-combustion engines, while this report sets forth the results obtained with peat when burned on the grate bars of two distinct types of steam generators.

Results show that under favorable conditions and circumstances peat fuel can be economically employed for the production of power by steam, but the controlling factor which determines the feasibility of using peat fuel for steam generation is the cost of producing this form of fuel and delivering it to the steam plant in a sufficiently dry state. Not only this cost of peat fuel delivered to the plant must be less than that of a quantity of good steam coal equivalent in heating value, but it is important to bear in mind that peat fuel, as commercially produced today, is much bulkier than coal equivalent in heating value. Hence, the problem of storage of peat fuel assumes important proportions.

Speaking generally, it is safe to say that peat fuel for steam-raising purposes cannot compete with good steam coal costing \$5 and less per ton. It appears, therefore, that in the majority of cases the more economical method of procedure with respect to peat utilization is the conversion of the peat fuel into a combustible gas which can be burned in a gas engine in this form, or used for the different heating furnaces in metallurgical work.

The above is taken from a preface to the investigation written by B. F. Haanel, Chief Engineer, Division of Fuels and Fuel Testing of the Department of Mines, Canada.

The trials themselves, described in the present report, were made partly on a Babcock & Wilcox water-tube boiler and partly on an internally fired boiler of portable locomotive type. The fuel used was manufactured by the Anrep process and had a moisture content of 16 to 20 per cent, which is rather low for this class of fuel. Hence, care should be taken when estimating the steaming properties of peat to allow for this fact. Further, the peat was of excellent quality, contained only a small percentage of dust, and throughout the series was hand-fired by an experienced fireman.

From tests on the water-tube boiler, conclusion is drawn that the most efficient grate bar would be one having an air space sufficiently large to permit the ash to fall through without taking an undue proportion of combustible with it.

It was also found that the ratio of free oxygen to combined oxygen in the flue gases increased with increased combustion per square foot of air opening. Probably, because as the draft increased, the supplementary air supply over the bars also increased, or it was the smaller air spaces that decreased the facility for the removal of ash by gravity, thus leaving the combustible portion of the fuel less accessible to the air.

As regards the flue-gas losses, the contents of carbon monoxide appear to be unusually high, and in addition to that, other gases were present. In fact, it may be taken as a rough approximation that the unused energy in these gases amounts to one-half of that remaining latent as carbon monoxide.

On the whole, the peat used proved to be a good fuel, easily handled and giving no trouble due to clinker or ash. It burned with a long flame and considerable light-colored smoke. The best results were obtained with the fuel consumption of 15 lb. per sq. ft. of grate, and the highest efficiency was obtained with the fuel highest in moisture content. Efficiency, however, was, on the whole, low, which may be attributed in part to the superheated steam in the flue gas, as well as losses due to unburned hydrocarbons and hydrogen. In fact, the total loss due to unburned gases was so high as to warrant the design of a large specially constructed combustion chamber in order to insure more complete combustion when burning this fuel.

Table 1 gives a synopsis of the results of trials with the water-tube and fire-tube boilers, respectively. (*Canada Department of Mines, Mines Branch Bulletin No. 17*, Ottawa, 1917, 42 pages, illustrated, *eA*)

TABLE 1 RESULTS OF TRIALS OF BOILERS FIRED WITH PEAT FUEL

	Water-tube Boiler			Fire-tube Boiler		
No. of Trial	71	72	73	83	84	85
Net calorific value of fuel as fired, B.t.u. per lb.	7490	7490	6990	7130	6970	7110
Peat fired per hour, lb.	476	586	569	160	214	341
Peat fired per sq. ft. of grate surface per hour, lb.	20.5	15.5	15.0	17.7	23.8	37.9
Equivalent evaporation per hour from and at 212 deg. fahr., lb.	1950	2322	2250	621	802	1054
Equivalent evaporation per hour per sq. ft. of heating surface, lb.	2.88	3.43	3.32	2.89	3.73	4.9
Pounds of dry flue gas per lb. of peat	12.4	9.8	11.1	9.8	9.1	6.5
Temperature in flue leaving boiler, deg. fahr.	720	760	715	690	690	750
Equivalent evaporation from and at 212 deg. fahr. per lb. of peat as fired, lb.	4.10	3.96	3.95	3.89	3.74	3.09
Thermal efficiency of boiler, furnace and grate, based on the net calorific value, per cent	53.1	51.3	54.8	52.9	52.1	42.2

Hydraulics

The Friction of Water in Iron Pipes and Elbows, F. E. Giesecke

Data and description of a series of experiments carried out by the Division of Engineering, Bureau of Economic Geology and Technology of the University of Texas, in November 1916, to determine the friction of water in standard American pipes and fittings.

The data are presented in the form of curves, expressing the friction of flow of water in various pipes at different velocities.

Equation showing the relation between the friction (h) and the velocity (v) for clean iron pipes ranging in size from ½ to 3 in. when the water has a temperature of about 68 deg. fahr. and flows at velocities up to 3 ft. per sec.:

$$h = 0.00685\frac{v^{1.77}}{d^{1.275}}$$

Friction of water at temperature of about 68 deg. fahr. in one standard short-radius steam elbow:

$$h = 0.0141\frac{v^{1.96}}{d^{0.26}}$$

From Fig. 5 the equations showing the relation between the friction and the velocity for 1¼-in. black pipe are for the line GH (below critical velocity)

$$h = 0.00925\ v^{0.873}$$

and for the line HI (above the critical velocity)

$$h = 0.004675\ v^{1.756}$$

Other pipes ranging in size from ½ to 3 in. were tested, the results plotted and the friction for 1 ft. of pipe was determined.

In order to derive an equation applicable to pipes of different sizes the coefficients and exponents of v in the equation

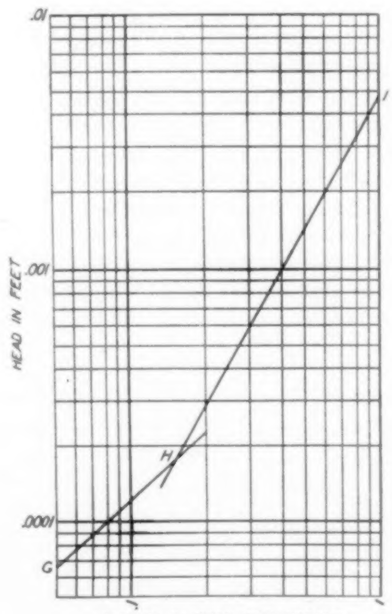


FIG. 5 DIAGRAM SHOWING THE FRICTION OF WATER IN 1 FT. OF PIPE AT DIFFERENT VELOCITIES

$h = kv^n$ were plotted, and from this diagram was derived the following approximate equation:

$$h = 0.00685\frac{v^{1.77}}{d^{1.275}}$$

(A more accurate equation is given in the original article.) This equation applies to water having a temperature of about 68 deg. fahr. flowing through clean iron pipes ranging in size from ½ in. to 3 in., and with velocities up to 3 ft. per sec.

A series of tests was also made to determine the effect of galvanizing and incrustation on the friction in pipes and equations were derived. From these tests it appears that the exponent of v in the expression for h increases with the roughness of the interior surface of the pipe. On the other hand, tests with water at temperatures varying from 70 to 140 deg. fahr. showed that the friction decreases as the temperature increases, and that the decrease is due to a change in the coefficient of v rather than to a change in the exponents.

An interesting series of tests was made to determine the friction in an elbow (Fig. 6). This friction may also be represented by the expression $h = kv^n$. The two heavy lines show, as nearly as possible, the average values of k and n, and from them the expression

$$0.0141\frac{v^{1.96}}{d^{0.26}}$$

was determined as representing the friction of water at the

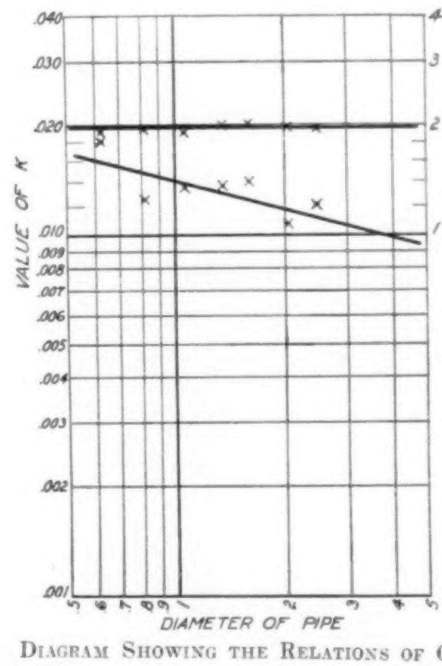


FIG. 6 DIAGRAM SHOWING THE RELATIONS OF COEFFICIENTS AND EXPONENTS OF v FOR ELBOWS OF DIFFERENT SIZES

temperature of about 68 deg. fahr. in one standard short-radius steam elbow.

In the original article a diagram is given showing the number of feet of straight pipe equivalent in friction to one elbow for any velocity of flow.

A bulletin giving a full report of the tests will be issued by the University of Texas as early as possible and will be sent free to all persons requesting a copy so long as the supply lasts. (*Journal of the American Society of Heating and Ventilating Engineers*, vol. 23, no. 4, July 1917, pp. 587-594, 6 figs. *et*)

HYDRAULIC BILLET BREAKER

Description of a 200-ton hydraulic billet breaker recently erected at a works in Yorkshire.

As shown in Fig. 7, the present machine, which is designed for breaking steel bars of 55 tons tensile strength into 16-in. lengths, has top and bottom notching blades provided in the form of an equilateral triangle, so that when worn they may be reversed in the dies and thus give three cutting edges. In this way the necessity for nicking the top side and then turning the billet over to break it is eliminated.

The bar to be cut is fed over a spring-supported roller, which carries it clear of the bottom knife and allows it to be fed up to the adjustable stop at the dead end. The ram which carries the top notcher is 20 in. in diameter and has a stroke of 12 in., with a working pressure of 1500 lb. per sq. in.

After the bar has been notched on both sides by a stroke of the ram, the lower knife, which has an easy fit in its die, is withdrawn by means of the handle and the bar is broken by a second stroke of the ram. The machine has an output capacity of 38 billets per hour. When dealing with particularly soft material it might be found necessary to turn the bar, so as to notch it on all four sides.

Attention is called to the fact that the operating lever is placed at the side and not at the front of the machine as in earlier designs. The ram is actuated direct from the pump, which is of the vertical three-throw type with plungers $2\frac{1}{2}$ in. in diameter by 6-in. stroke. It is driven by a 25-hp. motor through a double-helical gear enclosed in an oiltight casing.

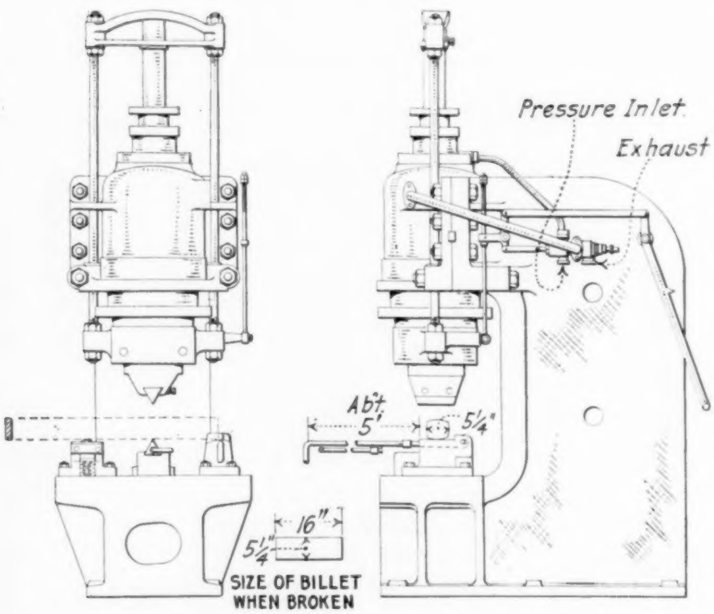


Fig. 7 British 200-Ton Vertical Hydraulic Billet Breaker

The pump plungers are fitted with a weight-controlled relief valve, and this weight is so arranged that it may be thrown over and thus relieve the pressure of the pump plungers when the breaker is not in actual duty. In this latter connection the writer mentions, however, that a serious defect in the use of this reliever device lies in the fact that experience has shown that such devices are seldom made proper use of so long as their neglect does not interfere with the proper operation of the plant. (*Page's Engineering Weekly*, vol. 31, no. 670, July 13, 1917, pp. 17-18, 2 figs., *d*)

Machine Shop

Surface Factor in Quenching Experiments, Lawford H. Fry, Mem.Am.Soc.M.E.

Data of experiments carried out with the purpose of studying the rate of cooling in various quenching media and of connecting the rate of cooling with the physical properties obtainable in quenched and tempered forgings.

The main series of experiments was carried out with two locomotive driving axles, which were drilled so that a pyrometer could be inserted and the temperature of the axle measured continuously during the process of quenching. One axle was 11 in. in diameter and forged solid. The other was 12 in. in diameter and bored longitudinally with a 3-in. hole. The quenching media experimented with were air, water, and heavy oil of 26 deg. B. gravity, a light oil of 29 deg. B. gravity, and three strengths of a cutting compound dissolved in water. This cutting compound, which was composed of mineralized lard, oil and soft soap, was used in solutions of 50 per cent, 33 per cent and 25 per cent. The cooling curves for twelve experiments are given in Fig. 8. Of these twelve experiments eight were made with a solid and four with a bored axle.

These curves indicate that the bored axle cooled more rapidly than did the solid axle in the same medium.

Further tests with a small test piece indicated that in a given medium the heat is given up by the big axle and the small test piece had practically the same rate in B.t.u. per sq. in. of surface, which makes it probable that fairly accurate information as to the quenching properties of a medium can be obtained from small-scale experiments.

It must be remembered, however, that the physical properties of steel are determined not by the rate at which heat is lost per unit of surface, but by the rate at which heat is lost per unit of weight, that is, by the rate at which temperature is

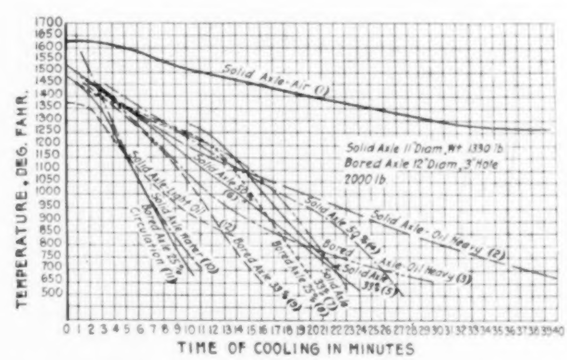


Fig. 8 Cooling Curves in Quenching Experiments

lost. From data presented in the paper it appears that the rate at which heat is lost per unit of surface is determined by the quenching medium, while the physical properties of the steel are determined at the rate at which temperature is lost. Furthermore, the rate of temperature loss depends both on the quenching medium and on the form of object quenched, the latter being the more important factor.

The writer, together with some other investigators, claims

In quenching, the rate at which heat is lost per unit of surface is determined by a quenching medium, but the physical properties of steel are determined by the rate at which temperature is lost, that is, the rate at which heat is lost per unit of weight.

The rapidity of cooling depends on:

a—Intimate contact between fluid and object to permit transfer of heat from object to fluid;

b—Free flow of fluid to remove heated or vaporized fluid from the surface of the object.

that the only scientific method of defining heat treatment in connection with physical properties is not to speak of "water quenching" or "air cooling," but to give the rate of temperature loss over a given range. To show how indefinite is the expression "air-cooled," the writer cites from the present test the fact that the test piece lost heat at the rate of 120 deg. per min. Hence, although the rate of cooling would be somewhat slower if it were averaged over a longer temperature range so as to include the recalescent period, still the rate at which the test piece cools in the air is of the same order as the rate at which the axle cools when quenched in water. Consequently the physical properties of the "air-cooled" test piece and the "air-cooled" axle will differ as widely as the properties of the "air-cooled" axle and of the "water-quenched" axle.

As regards the quenching speeds and composition of media, the experiments have not been complete enough to establish a theory of quenching action, but justify the conclusion that to have rapidity of cooling it is necessary to have first an intimate contact between fluid and object to permit transfer of heat from object to fluid, and second, free flow of fluid to remove heated or vaporized fluid from the surface of object.

A noteworthy feature is the great acceleration in cooling produced by a forced agitation of solution. Likewise the more rapidly cooling system produced with a light oil in comparison with heavy oil is evidently due to the greater fluidity of the former which enables more rapid convection currents to be set up and carry off the heat. (Paper before the Annual Meeting of the British Iron and Steel Institute, London, May 3-4, 1917, reprinted in the *American Drop Forger*, vol. 3, no. 7, July 1917, pp. 239-241, 1 fig., *e*)

Measurements

An Aneroid Calorimeter for Specific and Latent Heats, Nathan S. Osborne

The unstirred type of calorimeter has been embodied with important refinements in an instrument especially designed for determinations of specific heat and latent heat of refrigerating media. Heat developed and measured electrically is distributed automatically to the calorimeter and contents whose temperatures are measured by a platinum thermometer. Heat from other sources is excluded by a null method.

The calorimeter is adapted for use between minus 50 deg. and plus 50 deg. cent. In experiments where the measured heat added is used either to change the temperature of the contents or to evaporate a portion of the contents withdrawn as superheated vapor; in the first case, the specific heat of the liquid, and in the second, the latent heat of vaporization being obtained when proper corrections are made. (*U. S. Bureau of Standards*, Scientific Paper No. 301, advance abstract)

The Relative Sensibility of the Average Eye to Light of Different Colors and Some Practical Applications to Radiation Problems, W. W. Coblentz and W. B. Emerson

This paper gives data on the relative visibility of radiation of the average eye, based upon a group of 130 observers. The data were obtained by means of a flicker and an equality-of-brightness photometer. The energy evaluation of the light stimulus was made with great care.

The point of maximum visibility of the average eye is at $\lambda = 0.5576\mu$. A mathematical equation is given of the average visibility curve, which is applied in calculating the luminous energy emitted by a black body at various temperatures and the mechanical equivalent of light. The eye responds to light having an intensity less than 1×10^{-16} watt per cm^2 The paper describes tests on diffused light and on a physical photometer. A screen is described which transmits radiations proportional to the average eye. (*U. S. Bureau of Standards*, Scientific Paper No. 303, advance abstract)

Mechanics

Effect of Countershaft Speed Ratio on Power and Torque, Prof. A. Lewis Jenkins, Mem.Am.Soc.M.E.

A study of the two different combinations of countershaft speeds, back-gear ratios, and cone-pulley ratios for a pump-driven machine. An example is worked out for each combination, showing the belt speeds, horsepowers and spindle torques.

In the operation of cone-driven machines the consecutive spindle speeds may be obtained in a number of different ways by effecting various combinations of countershaft speeds, back-gear ratios and cone-pulley ratios. But there are two ways in use which require different cone-pulley ratios and ratios of countershaft speeds, and these are as follows:

First, the consecutive spindle speeds are obtained by starting with the slow countershaft speed, the largest back gear and the belt on the largest step of the head cone, which gives the first cone-pulley ratio. The change from the first, or slowest, to the second spindle speed is accomplished by merely changing the countershaft speed from slow to fast. For the next change of speed it is necessary to change the belt from the first to the second step on the head cone and change the countershaft speed from fast to slow. The fourth speed is then obtained by merely changing the countershaft speed from slow to fast.

The next case is where the back-gear ratios are used in the same way as in the preceding case, but the countershaft speeds and steps on the cones are not.

The slowest spindle speed is here obtained by using the slowest countershaft speed and the largest step on the head cone. In changing from the first to the second and from the second to the third spindle speeds it is only necessary to shift the belt from one step to the next. The fourth speed is obtained by using the fast countershaft speed with the belt on the largest step of the head cone, while the next two spindle speeds are obtained by using the second and third cone-pulley ratios with the fast countershaft speed.

The article gives formulæ for the back-gear ratios, cone-pulley ratios for duplicate cones and for the countershaft speeds.

An example is worked out numerically and covers the determination of the back-gear cone-pulley and countershaft speed ratios for a machine of given dimensions having three steps on the cone-pulley and two back-gear reductions. In this connection the comparative merits of the two systems outlined above are discussed. (*American Machinist*, vol. 47, no. 2, July 12, 1917, pp. 49-51, 3 figs., *tp*)

Railway Engineering

Brick-Arch Tests, Pennsylvania Railroad

Data of tests made by the Pennsylvania Railroad to show the value of the brick arch as a means of conserving fuel. These tests were made in Altoona on a Mikado-type locomotive.

The brick-arch equipment was of the Security sectional type. All tests were hand-fired, the fuel used being Jamison coal, bituminous high-volatile, sized by being passed over a screen having 1¼-in. openings. The screening and the use of coal from a single shipment were resorted to, because preliminary tests have demonstrated the need of uniformity in the size of coal for the tests.

On the whole, the tests have demonstrated marked advantages which can be ascribed to the use of the arch, summarized in the report as follows:

a The maximum evaporation when using high-volatile coal was increased 15.5 per cent by the use of the arch.

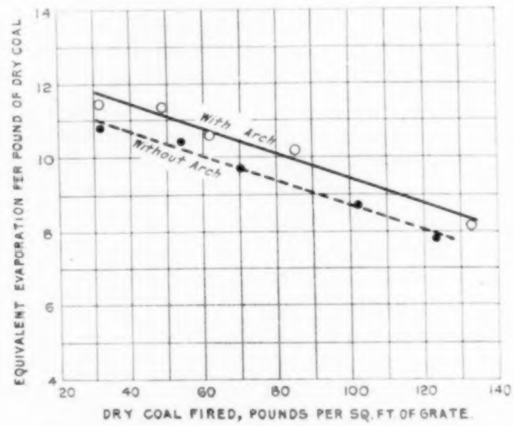


FIG. 9 RATE OF EVAPORATION PER POUND OF COAL, BRICK-ARCH TEST

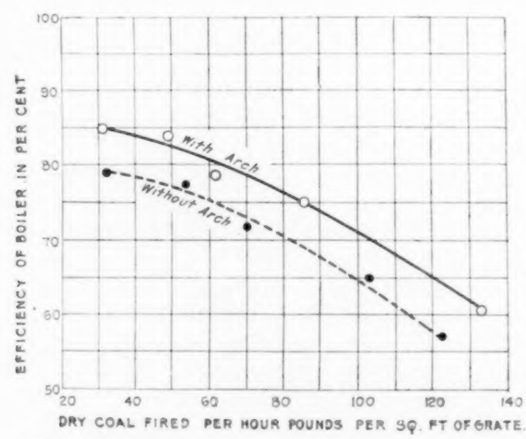


FIG. 10 RATE OF FIRING AND EFFICIENCY OF BOILER, BRICK-ARCH TEST

b With the arch a lower smoke density is measured by the Ringelmann scale.

c The arch increased the evaporation per pound of coal, and for ordinary rates of working this increase of evaporation represents an economy in coal of from 6 to 8 per cent.

This effect of the arch on evaporation was evident at all rates of combustion, as shown by Fig. 9. At maximum capacity the boiler when equipped with the arch was capable of evaporating 15.5 per cent more water than when without it.

d A higher boiler efficiency was made possible by the arch at all rates of evaporation. This is shown in Fig. 10. When plotted against the combustion rate, the factor of boiler efficiency shows an increase ranging between 6.9 and 11.6 per cent, with a rate of firing varying from 35 to 120 lb. of dry coal per sq. ft. of grate per hour. An examination of the values obtained between the limits common to road service indicate improvement under these conditions of from 7 to 8½ per cent. The report draws attention to the fact that other experimenters have found that the arch tubes alone, because of the added surface and improved circulation, afford improvement to the extent of about one per cent for each tube involved.

Because of the conditions under which the tests were made, that is, at fixed speed and cut-off, no noticeable economy was observed in the operation of the engine, but there was an increase in the power developed consequent upon the larger volume of steam flowing. On the basis of drawbar pull, it was found that at speeds above 8 m.p.h. the locomotive when equipped with the arch had an appreciable advantage. This advantage, measured at the maximum power developed, which was at the speed of 29 m.p.h., amounted to an increased drawbar pull of 2066 lb., or 6.4 per cent. (Pennsylvania Railroad Test Department Bulletin No. 30, abstracted through the *Railway Review*, vol. 61, no. 5, August 4, 1916, pp. 137-139, 3 figs., *e*)

Steam Engineering

CONDENSER-TUBE CORROSION, William Ramsay

A general discussion of the subject, together with data of observations and experiments made by the writer.

The writer does not ascribe much value to analyses of the defective tubes of a condenser after a breakdown. The analysis itself is a simple matter, but since the corroded matter has disappeared and the tube adjacent to the corroded part is, as a rule, normal, it does not give much material for the explanation. Further, the examination of the residue seldom points to anything useful, because the corrosion product contains the metals as basic chlorides, carbonates, oxides, or even sulphates, and much of this product is washed away in both soluble and insoluble form.

The writer made a number of experiments, many of which were abortive. The chief difficulty of experiments of this nature lies in the impossibility of reproducing actual working conditions. Even model condenser arrangements in which the same water is circulated many thousands of times failed to give the desired information. Such water may lose its corrosive properties, or, perhaps, become more corrosive with continued use, and the results are not likely to be conclusive.

The nature of brass corrosion is mainly, if not entirely, electrolytic in character, assisted by the fact that the commercial brasses are not homogeneous bodies, but are a kind of conglomerate.

Corrosion of a condenser tube may be said to commence from the moment it is put into use, and the extent to which it proceeds depends upon such factors as composition, time, temperature, water, etc.

The effect of corrosion in condenser tubes is varied. Copper and zinc may be removed uniformly from the surface, or, what is more commonly the case, zinc is dissolved out, leaving the copper or a copper-rich material as a coherent film, the original dimensions of the tube being nearly preserved. This is known as dezincification. In the case of the 60:40 tubes, the action takes place between the α and β constituents, and may proceed to completion, the tube retaining its original dimensions and to the naked eye preserving the appearance of a solid copper tube. On microscopic examination, however, it is seen to consist of coppery material, preserving the form of the α constituent, the space previously occupied by the β

being more or less filled by corrosion products, or possibly quite empty. In the case of 70:30 tubes, or Admiralty alloy, the action is probably somewhat different. Owing to some slight inequality in the composition, the equilibrium of the brass becomes upset and a more or less continuous film of copper results; electrolysis then takes place between the copper and the adjacent brass, resulting in a gradual concentration of copper. With these tubes dezincification is, as a rule, superficial.

Dezincification in itself is not a simple process. If some of the copper was in the solution, it may be redeposited as metallic copper on the brass, with an accumulative amount of zinc going into solution. The writer has proved that cuprous and cupric chlorides, oxide of copper and, in fact, most copper compounds are capable of depositing metallic copper on brass. The action of basic chloride of zinc is less clear, but on painting tubes with this material and immersing them in warm sea water, a distinct coppery stain results after some time. Dezincification may, therefore, at times even become protective.

It is an interesting fact that, if a portion of the coppery film be removed so as to expose the brass, it does not immediately become recoated with copper. A tube which had been dezinced to a depth of less than 1/500 in. was taken, and a small patch about ¼ in. sq. removed with fine emery paper, without appreciably altering the thickness of the tube. On immersing it in sea water kept warm, the brass rapidly corroded at this point until, in about a month, it was about 1/32 in. deep; copper then gradually encroached on the brass and stopped the action.

From this the writer proceeds to discuss the case of the so-called laminations in condenser tubes, due to defects in the manufacture of tubing, such as spills or blowholes in the original casting. On opening them up they are seen to be coated with oxide of copper, which, on immersing in sea water, is gradually reduced to the metallic state. This is probably the initial stage of electrolytic corrosion. Sooner or later the corroded lamination breaks away, exposing fresh lines of yellow brass. The following experiment was carried out to test the truth of the above. An Admiralty tube which showed indications of lamination was immersed in estuary water, which was changed almost every day over a period of more than two years, the containing flask being kept at a temperature of about 110 deg. to 150 deg. fahr. by means of an electric heater. After a few weeks the tube was completely coppered and the suspected lamination showed unmistakable signs of opening out. In about six months it had corroded away to a measurable extent, and several other lines of laminations, which had not been suspected, showed themselves. Throughout the test it was noticed that bubbles of gas adhered tenaciously to the laminations and the sharp edges of the tube. During the corrosion the lamination presented a varying appearance, at one time showing black lines, which cleared up to yellow brass or filmed over with copper through which minute specks of brass were visible, but at all times the action was greatest at the lamination and edges.

Likewise, due to defects in manufacturing, there are isolated holes in what may otherwise be perfect tubes. It is the opinion of the writer that these holes act in the capacity of corrosion centers.

The writer describes several sets of experiments, indicating that the strongest corrosion took place at, or near, the point of contact between two metals. Even metals, such as iron, zinc and lead, which are electropositive to brass, behave in this manner, which may be due to copper being redeposited on the foreign matter. It is noteworthy, in this connection, that magnetic oxide of iron, or metallic iron, coated with this oxide is sometimes electropositive, and at other times electronegative with reference to brass.

A form of corrosion of which the writer has definitely traced the cause is that which attacks the inlet ends for a few inches immediately beyond the tube plate. Here the cold circulating water, on becoming warm, deposits its dissolved gases; the part in the tube plate being kept cool, escapes this particular action, but just beyond this bubbles of CO_2 and air adhere to the tube, causing round each a ring of corrosion which eventually takes the form of a horseshoe, the open ends of which point in the direction of the water flow. This type of defect is most certainly due to the main condenser being used in harbor for the auxiliary machinery, when the smaller volume of steam does not necessitate the full-power circulation, and the friction of the water is insufficient to sweep away the deposited gases. Where an auxiliary condenser is used for port service this defect is obviated. Several rivers and harbors, and canals especially, have an evil reputation in this respect, all being more or less foul with sewage, while those with a good tidal scour are less objectionable. The accelerating effect of sewage, CO_2 and ammonia is well known.

In the original article is given a photograph of an opened-out tube which has suffered from this type of corrosion. It shows that, although the part in the tube plate is corroded, it has escaped the typical horseshoe action. The vessel from which this tube was taken was known to berth in a very dirty harbor. Dezincification is general all over the tube, and in the middle of each horseshoe, but where the corrosion is severe the brass remains yellow. This seems to point to the electrolysis between the separated copper and the brass.

There is another type of corrosion which affects the ends of the tubes and which may be found in any part of the condensers, and may occur singly or in groups. The extreme ends of the tubes are eaten away in the ferrules, which also may be involved; and in this case a curious accommodation between tube and ferrule often takes place, the more corroded part of the one fitting into the less affected part of the other, almost as if the action ceased when the pressure between the two had been relieved. This is most probably the case, since in cases of this type the writer has almost always observed that the tubes had been crushed or distorted by the ferrule. Physical condition as a factor in brass corrosion is fairly well established, and this seems a case which meets this theory. A condenser is generally tubed by several men, each taking a certain section or group of tubes, and it is not unlikely that one worker may have exerted such force as to bruise his tubes. This probably explains why such corroded ends generally occur in groups. (*Engineering*, vol. 104, no. 2689, July 13, 1917, pp. 40, 44-46, 7 figs., *eA*)

Thermodynamics

THE LATENT HEAT OF STEAM, Frank B. Aspinall

The writer starts by giving the following definitions of terms:

Steam is that which exists when absolutely no water and absolutely no superheat is present.

The *total heat of steam* is the exact quantity of heat present when absolutely no water and absolutely no superheat are present.

The *latent heat of steam* is the exact quantity of heat required to convert water from the form of water completely into the form of steam at the same temperature and pressure

as the temperature and the pressure of the water converted into the steam.

Heat latent is the varying heat latent when varying mixtures of steam and water are present.

The *steam volume* is the maximum volume which can be present without superheat being present.

The writer states that when he analyzed hundreds of indicator cards he noticed facts which were unexplainable, unless it be admitted that steam at high pressures containing absolutely no water and absolutely no superheat carried more heat and had a smaller volume than the steam tables stated.

A series of measurements was therefore made to ascertain the maximum heat and maximum volume which could be present without superheat being present, and this was the result:

The maximum heat which could be latent, or the latent heat of steam, was found to be constant, at a value nearly, if not actually, 970.13 B.t.u.

A steam volume multiplied by a steam pressure is constant, if steam is accepted as that which exists when absolutely no water and absolutely no superheat are present, the value stated in cubic feet and pounds absolute being nearly, if not actually, 399.84.

From these two constants the following conclusions were arrived at in regard to the steam tables:

The values stated for the total heat at atmospheric pressure apply to wet steam, the wetness increasing as the pressure increases. The values stated for the total heat at below atmospheric pressure apply to the superheated steam, the superheating increasing as the pressure decreases.

The values stated for the latent heat at above atmospheric pressure apply to the heat latent in mixtures of steam and water, the water increasing as the pressure increases.

The values stated for the latent heat at below atmospheric pressure apply to neither latent heat nor heat latent.

The values stated for the volumes at above 25 lb. absolute apply to superheated steam, the superheat increasing as the pressure increases.

The values stated for volumes at below 25 lb. absolute apply to wet steam, the wetness increasing as the pressure decreases.

The values are therefore not only not comparable in themselves, but are also not comparable to each other.

The late Dr. Silvanus Thompson was instrumental in having the Finsbury Technical College in London carry out, under the present writer's supervision, the determinations described in the article here abstracted.

The article describes in detail the conditions which were to be fulfilled during these tests, the method and apparatus used, observations and numerical results and the deductions arrived at. The following definitions were adopted for the terms employed:

The latent heat of steam is the amount of heat required to convert water, at a definite temperature and pressure, completely into steam at the same temperature and pressure as the water.

The sensible heat in steam is the heat in the water at the definite temperature and pressure at which it is converted into steam.

The total heat of steam is the latent heat plus the sensible heat, or the maximum heat which can possibly be present without superheat being present.

Wet steam is a mixture of steam and water in some form. The total heat present is therefore less than that which would be present if the water had been completely converted into steam.

Steam is all steam, the total heat present being the exact amount required for all the water to be converted completely into steam.

Superheated steam is all steam, the total heat present being more than the amount required at the given pressure and temperature for all water to be converted into steam.

The following formula was used to work out the latent heat of steam:

The latent heat of steam at the pressure P at the point $B =$

$$\frac{W(t_1 - t_2) - w(T - t_1) \pm j}{w}$$

P. As the supertemperature was so low, the observed pressure was accepted as the pressure of pure steam, but if the steam had been very highly superheated, a correction would have to have been made for the supertemperature.

W. In the first trials. The water present at commencement of the second blow + the water value of the metal.

In the second, third and fourth trials. The water present when the pipe was dropped into the water + the water value of the metal + the water value of the wood.

w. The actual weight present at the finish of the trial, minus the actual weight present at the commencement of the trial.

T. The mean corrected observed temperature of the thermometer in the long temperature well — the mean supertemperature.

t_1. The mean corrected observed temperature of the condensing water at the finish of the trial, as shown by thermometers, T.I., T.II., T.III. + the temperature the condensing water would have gained if it had not lost or received heat due to the surrounding air.

t_2. The mean observed corrected temperature of the condensing water at the commencement of the trial, as shown by thermometers T.I., T.II., T.III.

j. The difference between the superheat in the steam due to the supertemperature and the heat radiated from the lagged and bare pipe beyond the controlling valve admitting steam to the condensing water to within $1\frac{1}{2}$ in. above the maximum height of the water in the wooden vessel.

It will be noticed that the writer, like Southern and Regnault, makes no correction for possible changes in the specific heat of the boiler water. It appears, however, from the results of James Watt, Southern, and the writer, that the specific heat of water is constant *when water is subjected to the conditions present when a boiler is making steam.*

The method employed to determine the water value of the wooden vessel by the method of mixtures is described in detail.

Among other things, it has been found that even although extreme care was taken to prevent the steam from containing water just before it was wiredrawn, the small supertemperature obtained for such a large drop in pressure shows that water must have been present. There seems no other explanation than to conclude that *water can be present in steam in some form which is not a mechanical mixture.* This view also seems to be confirmed by the fact that for equal differences of pressure higher supertemperatures were usually obtained at 50 lb. than at 100 lb., which apparently shows that steam at a higher temperature can contain more water than at a lower temperature. The experiments seems to support the conclusion that *steam has a dewpoint like air.*

The Finsbury value for the latent heat of steam, or the

exact quantity of heat required to convert water from the form of water completely into the form of steam at the same temperature and pressure as the temperature and pressure of the water converted into the steam, is 969.67 B.t.u., a constant, per 1 lb. of steam. The writer takes, however, 969.90 as the constant latent heat of steam. This figure is the mean of the Blackheath value 970.13 and the above Finsbury value.

The writer proclaims the following basic laws:

It is the quantity of water present and not the temperature present which determines the quantity of heat which is latent.

The quantity of heat latent is a variable if water is present, because the maximum quantity of water which can be present increases as the pressure increases.

The evidence collected by the present writer leads him to believe that the heat latent when absolutely no water is present, or the latent heat of steam, is nearly, if not actually, 970 B.t.u. at all pressures.

Further, provided absolutely no water and absolutely no superheat are present, the pressure multiplied by the volume is always nearly, if not actually, 400.

The writer concludes by calling attention to the fact that James Watt distinguished between latent heat and heat latent, and believes that all the trouble has arisen owing to Regnault not making this distinction. (*The Engineer*, vol. 124, nos. 3210, 3211, 3212, July 6, 13 and 20, 1917, *tA*)

VENTILATION STANDARDS AND THE SYNTHETIC AIR CHART, Dr. E. V. Hill

The writer claims that one of the problems of modern ventilation is not so much *how* to accomplish the desired need, but *how to know* when that end has been attained. In other words, the need is for improvement not in mechanical equipment, but in methods of testing to determine with greater accuracy what the equipment accomplishes, and more than all else, satisfactory standards by which conditions may be compared. The development of a satisfactory air-condition test record, however, is made difficult through the fact that combinations might occur that when plotted would be misleading. Such a test record must cover at least temperature, air movement and humidity, and there is a definite relation between the *variations* of these elements that it is difficult to show accurately on the chart.

In fact, after giving this matter considerable study, the writer came to the conclusion that more definite information regarding the relations of temperature, humidity and air motion to each other in their bearing on comfort must be secured before a workable chart could be designed. To do this a room in a factory building was equipped so that any combination of temperature, humidity and air motion could be maintained and their relations approximately determined.

On the whole, it has been found that, first, comfort depends upon air conditions that allow the normal heat losses from the body without the undue exercise of heat-regulating mechanism. Second, other things being equal, the heat loss is approximately constant if the wet-bulb temperature is constant. And third, the comfortable wet-bulb temperature increases with the air motion.

On this basis two synthetic air charts were developed, of which the second, introducing air-motion curves, is reproduced in Fig. 11. The theory on which the chart is based is that the factors which determine ventilation of a given space may be conveniently combined into three principal groups, as follows: (1) Temperature, humidity and air motion; (2) Dust, bacteria and odors; (3) Air supply and carbon dioxide.

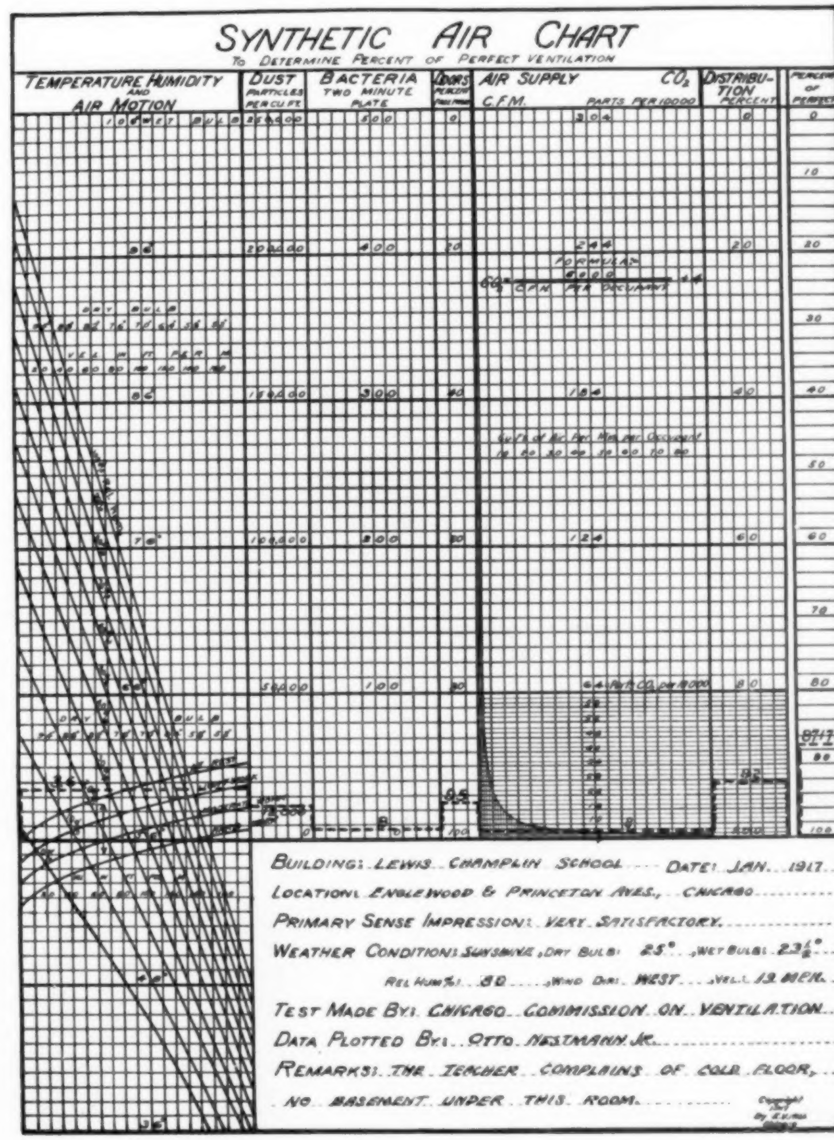


FIG. 11 SYNTHETIC AIR CHART

The use of the chart in Group 1 is as follows: From test data is noted the wet-bulb temperature. This is indicated by the horizontal line connecting this wet-bulb temperature and the appropriate air-motion curve. Next is noted from test data the air motion prevailing, and the appropriate air-motion curve is connected by a horizontal line with the wet-bulb that is desired for this velocity. The number of squares between these two horizontal lines across this portion of the chart is the amount of penalization. (*Journal of the American Society of Heating and Ventilating Engineers*, July 1917, p. 477, *ep*)

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U. E. S. Accessions

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American Railway Engineering Association. Manual, 1915. Gift of Association.

Annual Chemical Directory of the United States. B. F. Lovelace, Editor, Baltimore, Williams & Wilkins Co., *Baltimore, 1917.* Cloth, 6 x 9 in., 305 pp., $5. Gift of the publisher.

Applied Mechanics. By Alfred Poorman. McGraw-Hill Book Co., Inc., *New York, 1917.* Cloth, 6 x 9 in., 244 pp., 321 figs. $2. Gift of the publisher.

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Arithmetic for Engineers. By Charles B. Clapham. E. P. Dutton & Co., *New York, 1916.* Cloth, 6 x 9 in., 436 pp., 149 figs., $3. Gift of the publisher.

Artificial Electric Lines; Their Theory, Mode of Construction and Uses. By A. E. Kennelly. McGraw-Hill Book Co., Inc., *New York, 1917.* Cloth, 6 x 9 in., 348 pp., 117 figs., $4. Gift of the author.

Ayer's American Newspaper Annual and Directory. *Philadelphia, 1917.* Purchase.

Baltimore (Md.) City Officers and Departments. Reports made to the City Council, 1915. *Baltimore, 1916.* Gift of City Librarian.

Battle Fire Training. By Capt. G. S. Turner and Capt. J. J. Fulmer. George Banta Publishing Co., *Menasha, Wis.* Cloth, 4 x 7 in., 294 pp., 47 illus. $1. Gift of the publisher.

Bauxite and Fullers Earth of the Coastal Plain of Georgia, Report on. (Ga. Geological Survey. Bulletin no. 31) *Atlanta, 1917.* Purchase.

Binghamton (N. Y.) Common Council. Official Proceedings. 1912-1916. *Binghamton, 1912-16.* Gift of City Clerk.

Boston Society of Civil Engineers. Constitution and By-laws and List of members. June, 1917. *Boston, 1917.* Purchase.

British Columbia, Minister of Mines. Annual Report, 1916. *Victoria, 1917.* Purchase.

British Columbia. Water Rights Branch. Report, 1916. *Victoria, 1917.* Gift of Water Rights Branch.

Buffalo (N. Y.) Department of Public Works. Annual Report (23d), 1914-15. *Buffalo, 1915.* Gift of Department of Public Works.

Building Superintendence for Steel Structures. By Edgar S. Belden. American Technical Society, *Chicago, 1917.* Cloth, 5 x 8 in., 95 pp., 26 figs. $1. Gift of the publisher.

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Chemical Discovery and Invention in the Twentieth Century. By Sir William A. Tilden. E. P. Dutton & Co., *New York, 1916.* Cloth, 6 x 9 in., 487 pp., 161 illus., $3.50. Gift of the publisher.

Chemical Tests for Minerals. By Arthur J. Burdick. The Gateway Publishing Co., *Beaumont, Cal., 1917.* Cloth, 5 x 8 in., 93 pp. $1.25. Gift of the publisher.

Chicopee, Mass., Municipal Register. 1912-1916. *Chicopee, 1912-16.* Gift of City Clerk.

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Compressed Air; Theory and Computations. By Elmo G. Harris. 2d ed., McGraw-Hill Book Co., Inc., *New York, 1917*. Cloth, 6 x 9 in., 192 pp., 32 figs. $2. Gift of the publisher.

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Council Bluffs, Iowa. Mayor's annual message with accompanying documents. 1914. Gift of Department of Finance and Municipal Accounts.

Determination of Nitrogen in Substances Used in Explosives. (U. S. Bureau of Mines. Technical Paper 160) *Washington, 1917*. Purchase.

Detroit, Mich., Department of Public Works. Annual Report (42d), 1916. *Detroit, 1916*. Gift of Department of Public Works.

The Disposal of Household Wastes. By Wm. Paul Gerhard. 3d ed. D. Van Nostrand Co., *New York, 1915*. Boards, 4 x 6 in., 195 pp., 4 figs. $0.50. Gift of the publisher.

Dyestuff Situation in the United States, Nov., 1915. U. S. Department of Commerce. Special Agents series, no. 111. *Washington, 1916*. Purchase.

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Electrical Measurements in Practice. By Malcolm Farmer. McGraw-Hill Book Co., Inc. *New York, 1917*. Cloth, 6 x 9 in., 359 pp., 230 figs. $4. Gift of the publisher.

Electric Railway Transportation. By Henry W. Blake and Walter Jackson. McGraw-Hill Book Co., Inc. *New York, 1917*. Cloth, 6 x 9 in., 487 pp., 120 figs., $5. Gift of the publisher.

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Evansville, Indiana. Annual Reports, 1913, 1915, 1916. Gift of City Comptroller.

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Gas and Fuel Analysis for Engineers. By August H. Gill. 8th ed. John Wiley & Sons, Inc., *New York, 1917*. Cloth, 5 x 7 in., 145 pp., 20 figs. $1.25. Gift of the publisher.

Gas-Lighting and Gas-Fitting: A Pocket Book for Gas Engineers, Gas Fitters, etc. By Wm. Paul Gerhard. 4th ed. D. Van Nostrand Co., *New York, 1913*. Boards, 4 x 6 in., 190 pp., 3 figs. $0.50. Gift of the author and publisher.

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Grand Rapids (Mich.) Board of Public Works. Annual Reports (42d-43d), 1915-16. Gift of Board of Public Works.

Gray's Plumbing Design and Installation. By William Beall Gray. David Williams Co., *New York, 1916*. Cloth, 6 x 9 in., 559 pp., 500 figs. $4. Gift of U. P. C. Book Co.

Heaton's Annual; The Commercial Handbook of Canada and Boards of Trade Register (13th Year). Heaton's Agency, *Toronto, 1917*. Cloth, 5 x 7 in., 518 pp. $1.25. Gift of the publisher.

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How to Study. By George Fillmore Swain. McGraw-Hill Book Co., inc., *New York, 1917*. Paper, 5 x 7 in., 65 pp. $0.25. Gift of the publisher.

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Interborough Finance; Present and Future, Including Synopsis of the Financial Structure of Interborough Consolidated Corporation. Van Emburgh & Atterbury, *New York, 1917*. Leather, 6 x 9 in., 69 pp., 2 maps, 2 diagrams, Gift of the publisher.

Introduction to the Rarer Elements. By Philip E. Browning. 4th ed. John Wiley & Sons, Inc. *New York, 1917*. Cloth, 6 x 9 in., 250 pp., 6 figs. $2. Gift of the publisher.

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Macon, Ga., Annual Reports of Officers, 1913, 1916. Macon, Ga. *1913, 1916*. Gift of City Clerk.

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Mechanical Appliances Mechanical Movements and Novelties of Construction. By Gardner D. Hiscox. 4th ed. The Norman W. Henley Publishing Co., *New York, 1917.* Cloth, 6 x 9 in., 396 pp., 1000 figs. $3. Gift of the publisher.

Mechanical Movements, Powers and Devices; A Treatise Describing Mechanical Movements and Devices Used in Constructive and Operative Machinery and the Mechanical Arts. By Gardner D. Hiscox. The Norman W. Henley Publishing Co., *New York, 1917.* Cloth, 6 x 9 in., 409 pp., 1800 figs. $3. Gift of the publisher.

Merchants' Association of New York. Supplement no. 33 for brief of arguments against public ownership. Nov., 1916. Gift of American Telephone & Telegraph Co.

Military Sketching and Map Reading. By Capt. Loren C. Grieves. U. S. Infantry Association, *Washington, D. C., 1917.* Cloth, 6 x 9 in., 95 pp., 32 figs. $1. Gift of the publisher.

Missouri Bureau of Geology and Mines. Biennial Reports of the State Geologist. 1917. Purchase.

The Modern Gas Tractor; Its Construction, Utility, Operation and Repair. By Victor W. Page, 2d ed. The Norman W. Hanley Publishing Co., *New York, 1917,* Cloth, 5 x 7 in., 504 pp., 225 figs. $2. Gift of the publisher.

Modern Milling: A Practical Manual on Milling Machines, Milling Accessories and Milling Operations. By Ernest Pull. The Macmillan Co., *New York, 1917.* Cloth, 6 x 9 in., 207 pp., 188 figs. $3. Gift of the publisher.

Monograph of the Foraminifera of the North Pacific Ocean. Pt. VI—Miliolidae. U. S. National Museum. Bulletin 71. *Washington, 1917.* Purchase.

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Moody's Manual 1917—Industrials. *New York, 1917.* Purchase.

Moody's Manual Complete List of Securities Maturing, July 1, 1917- June 30, 1919. Vol. IV. *New York, 1917.* Purchase.

Montclair (N. J.) Town Council. Annual Report, 1911. Gift of City Clerk.

Motor Boats, Hydroplanes, Hydroaeroplanes; Construction and Operation with Practical Notes on Propeller Calculation and Design. By Thomas H. Russell. Charles C. Thompson Co., *Chicago, 1917.* Cloth, 5 x 8 in., 254 pp., 106 figs. $1. Gift of the publisher.

National Association of Railway Commissioners. Proceedings of the 28th Annual Convention, Washington, D. C., Nov. 14-17, 1916. *New York, n. d.* Purchase.

National Industrial Conference Board. Summary of report on workmen's compensation acts in the United States. April, 1917. Gift of Board.

National Tube Company. "National" Pipe Standards. *Pittsburgh, 1917.* Gift of National Tube Company.

Naval Architecture. By Cecil H. Peabody. 4th ed. John Wiley & Sons, Inc., *New York, 1917.* Cloth, 6 x 9 in., 641 pp., 218 figs. $7.50. Gifts of the publisher.

Navigation Laws. Comparative study of principal features of the laws of the United States, Great Britain, Germany, Norway, France and Japan. U. C. Department of Commerce. Special Agents series no. 114. *Washington, 1916.* Purchase.

New Jersey Department of Conservation and Development. Annual Report for the year ending Oct. 31, 1916. *Trenton, N. J., 1917.* Gift of Department of Conservation and Development.

North Adams, Mass. City Clerk. Annual Reports, 1912-1916. *North Adams, 1912-16.* Gift of City Clerk.

Ohio Engineering Society. Report of the 38th annual meeting, 1917. *Norwalk, 1917.* Gift of Society.

Omaha, Nebraska, Department of Accounts and Finances. Report 1910-11, 1912-14. Gift of Superintendent of Accounts and Finances.

Organizing and Conducting Safety Work in Mines. U. S. Bureau of Mines. Technical Paper 103. *Washington, 1917.* Purchase.

Ottawa, Canada. Annual Departmental Reports for the Corporation, 1912. *Ottawa, 1912.* Gift of City Clerk.

Outlines of Industrial Chemistry; A Text-Book for Students. By Frank Hall Thorp, with assistance in revision from Warren K. Lewis. 3d ed. The Macmillan Co., *New York, 1916.* Cloth, 6 x 9 in., 665 pp., 137 illus. $3.75. Gift of the publisher.

The Panama Canal and Commerce. By Emory R. Johnson. D. Appleton & Co., *New York, 1916.* Cloth, 5 x 7 in., 295 pp., 8 illus., 7 maps. $2. Gift of the publisher.

Passaic, N. J. Financial Report, 1910, 1912-1916. Gift of City Clerk.

Pennsylvania. Commissioner of Health. Annual Report. 1914, Part I-II. *Harrisburg, 1916.* Purchase.

Pennsylvania. Commissioner of Labor and Industry. Annual Report (2d), 1915, Part II. *Harrisburg, 1916.* Purchase.

Pennsylvania Company. Annual Report (45th), 1917. *Pittsburgh, 1917.* Gift of Pennsylvania Co.

Pennsylvania State College. Annual Report, 1914-15. *Harrisburg, 1916.* Purchase.

A. S. M. E. Accessions

American Wool Preservers' Association. Report of Proceedings 13th Annual Meeting, 1917. Gift of Association.

Co-Partnership After the War. A Memorandum Submitted Feb., 1917, to the reconstruction committee appointed by H. M. Government.

Industrial Fatigue in Its Relation to Maximum Output. By Henry J. Spooner.

Investigation of the Municipal Light Plant, Report of. By C. W. Whiting, *Boston, 1917.*

Metropolitan Water and Sewerage Board. Annual Report (16th). *Boston, 1917.* Gift of Board.

National Board of Fire Underwriters. Address of R. M. Bissell, May 24, 1917.

National Machine Tool Builders' Association. Proceedings of Annual Convention, 1915-1916. Gift of Association.

New Orleans, La. Sewerage and Water Board. Report (34th semi-annual), 1916. Gift of New Orleans Sewerage and Water Board.

New York (City) Board of Water Supply. Information for bidders for vitrified brick pavement in the Kensico Aerator in the town of Mt. Pleasant, Westchester Co., N. Y. (Contract 184.) 1917.

—— —— for surfacing with vitrified brick block the East Hill Drive at the Kensico Dam in the town of North Castle, Westchester Co., N. Y. (Contract 179.)

—— —— for the completion of the superstructure over the drainage chamber at shaft 21 of the City Tunnel of the Catskill Aqueduct, in the Borough of Manhattan, 1917. (Contract 129.)

—— —— for erecting, remodelling and removing buildings along the Catskill Aqueduct. (Contract 180.) Gift of the New York City Board of Water Supply.

Second Pan-American Scientific Congress. The Report of the Secretary General. *Washington, 1917.*

PERSONALS

IN these columns are inserted items concerning members of the Society and their professional activities. Members are always interested in the doings of their fellow-members, and the Society welcomes notes from members and concerning members for insertion in this section. All communications of personal notes should be addressed to the Secretary, and items should be received by September 16 in order to appear in the October issue.

CHANGES OF POSITION

E. E. ARNOLD has left the employ of The New Departure Manufacturing Company, Bristol, Conn., and is now affiliated with the Iron City Products Company, Pittsburgh, Pa.

A. R. DICKINSON, formerly connected with the Mill Management Department of Lockwood, Greene and Company, Atlanta, Ga., has become identified with the Winnsboro Mills, Winnsboro, S. C.

DR. BARTON CRUIKSHANK has severed his connection with The Engineers' Company of New York, and is now designing engineer of the Maxim Munitions Corporation, Watertown, N. Y.

EDWIN S. BOYER, until recently with Walter Kidde and Company, of New York City, has identified himself with the American Hard Rubber Company, of the same city.

CHARLES C. HOKE, formerly engineer with the Cia Minerales y Metales, Laredo, Tex., has accepted a position with the Compania Minera de Penoles, Mapimi, Tex.

W. C. KERR is now affiliated with the Republic Railway and Light Company of New York City. He was formerly in the employ of the Philadelphia Rapid Transit Company, Philadelphia, Pa.

S. HOWARD SWEET has resigned from the Remington Arms-Union Metallic Cartridge Company, and has joined the Oil Engine Company, Bridgeport, Conn., in the capacity of chief engineer.

RAYMOND W. MULLER, recently assistant maintenance engineer with the Bosch Magneto Company, New York City, has joined Walter Kidde and Company in the capacity of mechanical engineer.

GEORGE B. MALONE has resigned from the Winchester Repeating Arms Company, New Haven, Conn., to take charge of the welding department of the Remington Arms Company, Bridgeport, Conn.

GEORGE W. HAWKINS has identified himself with Anderson, Meyer and Company, Ltd., Shanghai, China. He was formerly Tucson manager of Chas. C. Moore and Company, San Francisco, Cal.

WILLIAM E. ANDERSON, formerly designer with the Alberger Pump and Condenser Company, of New York City, is now associated with the A. S. Cameron Steam Pump Works, Phillipsburg, N. J.

W. A. J. LONDON has severed his connection with the General Electric Company, West Lynn, Mass., to become engineer with the Steam Motors Company, Inc., Springfield, Mass.

W. H. RIPLEY, for several years associated with the Griscom-Russell Company as sales engineer and evaporator expert, has been appointed sales agent for the Nashua Machine Company, Nashua, N. H., to succeed the late W. E. Van Keuren.

C. C. HINKLEY has severed his connection as chief engineer with the Chalmers Motor Car Company, Detroit, Mich., and is now president and general manager of the Hinkley Motors Corporation of the same city.

HENRY M. WOOD, formerly with The Lodge and Shipley Machine Tool Company, Cincinnati, Ohio, has assumed the duties of vice-president and general manager of The Maim and Wood Machine Company, Dayton, Ohio.

CHARLES L. BRUFF has severed his connection with the United Gas Improvement Company, Philadelphia, Pa., and has taken up consulting engineering work, making a specialty of power-plant economy work.

GEORGE H. SHARPE has accepted the position of chief engineer with the Westcott and Mapes Company, New Haven, Conn. He was, until recently, mechanical engineer with the New York Central Railroad, Heat and Power Department.

A. H. GILL, formerly superintendent of the Perth Amboy plant of the American Smelting and Refining Company, Metuchen, N. J., has taken a position with the American Zinc and Chemical Company, Langeloth, Pa.

CHARLES J. MANUEL has resigned from his position with F. W. Bird and Sons, East Walpole, Mass., and has assumed the duties of draftsman of the tool department of the Aeromarine Plane and Motor Company, Keyport, N. J.

G. C. VENNUM, formerly assistant chief engineer of power plants, Union Electric Light and Power Company, St. Louis, Mo., is now associated with the Electric Bond and Share Company, New York City, in the capacity of mechanical engineer.

JOHN F. GLENN, contracting engineer for the past seven years with the Wickes Boiler Company, Buffalo, N. Y., is now New England sales manager for the Edge Moor Iron Company, manufacturers of the Edge Moor water-tube boiler, Boston, Mass.

EDMUND BARANY, machine designer of the Singer Manufacturing Company, Elizabeth, N. J., has assumed the duties of assistant mechanical engineer of the Cleveland Twist Drill Company, Cleveland, Ohio.

JOHN H. MCNALLY until recently district manager of the Kokomo Foundry and Machinery Company, Philadelphia, Pa., has accepted a position as fuel engineer with Weston Dodson and Company, Inc., Bethlehem, Pa.

FRANK GENTLES, until recently in the engineering department of the Chester Shipbuilding Company, Ltd., Chester, Pa., has become affiliated with the engineering department of the Emergency Fleet Corporation, Washington, D. C.

HAROLD B. BERNARD has resigned his position with the Oklahoma Petroleum and Gasoline Company, Tulsa, Okla., to accept the position of superintendent of the gasoline department of the Sinclair Oil and Gas Company, of the same city.

CHARLES W. STEPHEN, in charge of experimental work and testing of materials with the Bridgeport, Conn., division of the Crane Company, has severed his connections with the company and has accepted a position with the Pratt and Cady Company, Hartford, Conn.

HARRY T. ANDERSON, formerly assistant in the tool-design department of the Simplex Auto Company, New Brunswick, N. J., has become identified with the Colt's Patent Firearms Manufacturing Company, Hartford, Conn.

HOMER W. GOODIER, formerly mechanical engineer with the Cayuga Cement Corporation, Portland Point, N. Y., has become connected with the Pierce-Arrow Motor Car Company, Buffalo, N. Y., in a similar capacity.

B. M. W. HANSON, vice-president and works manager of the Pratt and Whitney Company, Hartford, Conn., has resigned after nineteen years' service with the company and has accepted a similar position with the Colt's Patent Firearms Manufacturing Company, of the same city. Mr. Hanson has also resigned from the machine-gun board appointed by the U. S. Government, but he will continue to give the latter the benefit of his services, as far as his new duties will permit.

FRANK H. CROCKARD, vice-president of the Tennessee Coal, Iron and Railroad Company since 1906, recently tendered his resignation, effective July 1, to accept the presidency of the Nova Scotia Steel and Coal Company, and will have charge of plans for a considerable extension of the company's operations. H. C. Ryding, who has served as Mr. Crockard's assistant for the past ten years, has succeeded to the position of vice-president of the Tennessee Coal, Iron and Railroad Company.

ANNOUNCEMENTS

A. P. BRUSH, of the Brush Engineering Association, has been selected by the Studebaker Corporation to serve as consulting engineer.

H. WADE HIBBARD, professor of mechanical engineering, University of Missouri, is now in Washington with the National Council of Defense.

L. E. WALKER, formerly district manager of the Good Roads Machinery Company, Philadelphia, Pa., is now sales engineer of the same company.

CRANDOR D. GATES, who was associated with the Celluloid Company, Newark, N. J., in the capacity of chief draftsman, is now assistant works superintendent of the same concern.

EDWARD F. ENTWISLE, mechanical engineer at the Bethlehem Steel Company, Steelton, Pa., has been promoted to the general superintendency of the Donaghmore plant at Lebanon.

J. LEO MAYER, formerly connected with the Zanesville, O., works of the Mark Manufacturing Company, has become affiliated with the Indiana Harbor, Ind., office of the same company.

T. S. BAILEY, until recently with the Electric Boat Company at Groton, Conn., is now connected with the San Francisco, Cal., works of the same company.

ALVAH H. SABIN, consulting chemist of the National Lead Company, New York, and lecturer at New York University, was given the degree of Doctor of Science by Bowdoin College, June 21.

EARL N. MATTSON has been transferred to the Birmingham office of the American Cast Iron Pipe Company. He was until recently connected with the Chicago, Ill., office of the company.

GEORGE RAMSEY, senior member of the patent law firm of Ramsey and Parmelee, of Washington, D. C., is now in charge of the new office of the firm in New York.

WILLARD DOUD has accepted a commission as Lieutenant (Junior Grade) in the United States Naval Reserve Force, and has been assigned to active duty at the Naval Training Station, Great Lakes, Ill.

FRANK G. COX, until recently New England sales manager of the Edge Moor Iron Company, is now located in New York City as New York sales manager for the same company.

R. M. DYER, president of the Pacific Northwest Society of Engineers, addressed the June 28 meeting of The Engineers Club of Seattle, on Wooden-Ship Construction.

CLARENCE E. BIRKENBEUL, recently with The Holt Manufacturing Company, Stockton, Cal., as draftsman, has accepted a position with Meese and Gottfried of San Francisco, Cal.

JAMES OGG, with the American Cuban Estates Corporation, Santa Clara, Cuba, has become associated with the Honolulu Iron Works Company, Honolulu, Hawaii.

LOUIS E. KENFIELD, until recently mechanical engineer with R. Hoe and Company, New York, has entered the employ of The Locomobile Company of America, Bridgeport, Conn., in the capacity of chief tool designer.

HUGH P. FELL has assumed the duties of general superintendent of the Kings County Lighting Company, Brooklyn, N. Y. He was until recently associated with the Electric Bond and Share Company, New York.

WALTER H. VOLKMAR has severed his connections with the New England Westinghouse Company of Springfield, Mass., and is now with Baker, Sutton and Harrison, New York, industrial engineers and public accountants.

JAMES D. REIFSNYDER, formerly affiliated with the Stokes and Smith Company, Philadelphia, Pa., in the capacity of chief engineer, has assumed the duties of vice-president and manager of the Gefes Machine Company, Hoboken, N. J.

NEWMAN COMFORT has been transferred from the position of O io branch manager of the National Workmen's Compensation Service Bureau to that of Louisiana branch manager of the same bureau, with offices in New Orleans, La.

THOMAS CHESTER is now special representative, handling U. S. Navy business for the American Blower Company, with headquarters in New York. He was formerly associated with the Detroit, Mich., office of the same company.

B. B. MILNER, engineer of motive power of the New York Central at New York, will hereafter also perform the duties heretofore performed by the chief mechanical engineer, R. B. Kendig, deceased. The office of chief mechanical engineer has been abolished.

EDWARD J. KUNZE has resigned his position as professor of mechanical engineering at Oklahoma Agricultural and Mechanical College, to accept the commission of captain in the Quartermaster Officers' Reserve Corps, and has been ordered to Fort Sam Houston, Tex., for duty.

JOHN A. BRITTON, in addition to his present duties on the California State Council for Defense, will also serve on the national committee on gas and electric service, of which JOHN W. LIEB, of the New York Edison Company, is chairman.

AMOS WHITNEY, founder of the Pratt and Whitney Company, Hartford, Conn., was tendered a complimentary dinner by 40 members of the "Old Guards" at the Farmington, Conn., Country Club, June 20, in celebration of his eighty-fifth birthday.

B. F. RABER, associate professor of mechanical engineering and B. M. Woods, assistant professor of theoretical mechanics at the University of California, have returned from a governmental commission to Toronto, and are assisting in instituting a curriculum on military aeronautics at the State University.

THOMAS MORRIN, consulting mechanical engineer of San Francisco, Cal., announces that he has now associated with him, as partner, Albert A. Coddington, and that the business will hereafter be conducted under the firm name of Morrin and Coddington, consulting mechanical engineers.

THOMAS E. DURBAN has severed his connection with the Erie City Iron Works, Erie, Pa., as general manager, and has opened an office in the same city for the conduct of the affairs of the American Uniform Boiler Law Society, of whose Executive Council Mr. Durban is Chairman. This society was organized for the purpose of promulgating the A.S.M.E. Boiler Code.

HENRY M. LELAND, president of the Cadillac Motor Car Company, Detroit, Mich., and his son, Wilfred C. Leland, whose names have been connected so prominently with the perfection of gasoline engines, have announced their retirement from the automobile industry to devote their time and interests to the call of the nation. They are dedicating their services to the task of building up a powerful aeroplane fleet that will give the United States mastery of the air in the present war.

DAVID L. GALLUP, professor of gas engineering at Worcester Polytechnic Institute, Worcester, Mass., left for Indianapolis, July 1, to establish a research and consulting department for the Nordyke and Marmon Company, builders of the Marmon motor car. Professor Gallup will temporarily take the place of Howard Marmon who is going to France as an aircraft engineer of the aeroplane division of the United States Army.

APPOINTMENTS

A. R. MCARTHUR, resident engineer of the American Sheet and Tin Plate Company, at Gary, Ind., has been appointed a member of the School Board of that city.

D. MCCALL WHITE, formerly chief engineer of the Cadillac Motor Car Company, Detroit, Mich., has been appointed consulting engineer to the General Motors Company and will work closely with all of the General Motors divisions.

AUTHORS

FREDERIC G. COBURN has contributed an article on The Work of Management to the July number of *Industrial Management*.

H. F. STRATTON is the author of New Starters for Induction Motors, which appeared in the July 12 issue of *The Iron Trade Review*.

CHARLES M. HORTON has contributed an article on The Reason for Efficiency "Experting" to the July number of *Industrial Management*.

WALTER D. FULLER has contributed an article entitled Standardization in Office Work to the July issue of *Industrial Management*.

C. E. KNOEPPEL is the author of The Industrial Engineer and Preparation for War, which appeared in the July number of *Industrial Management*.

HALBERT P. GILLETTE has contributed an article entitled Logic for Engineers—Induction and Deduction, to the July 4 issue of *Engineering and Contracting*.

A. LEWIS JENKINS is the author of Effect of Countershaft Speed Ratio on Power and Torque, which appeared in the July 12 issue of the *American Machinist*.

THE NEW BOOKS

ALL books received by The Journal will be listed under this heading, generally accompanied by brief descriptive notes. Works of special importance to mechanical engineers will be commented on at length by members and others peculiarly qualified by reason of their experience and training.

Manufacture of Artillery Ammunition

Manufacture of Artillery Ammunition. By Members of the Editorial Staff of the *American Machinist*: L. P. Alford, Editor-in-Chief; F. H. Colvin, Ethan Viall, Robert Mawson, E. A. Suverkrop and John H. Van Deventer. McGraw-Hill Book Co., Inc., New York, 1916. Cloth, 6 x 9 in., xii+759 pp., 648 illustrations. $6 net.

This book is an excellent volume from a practical viewpoint of how the average shop equipment can be readily converted into a shop for the manufacture of munitions.

As a reference book for dimensions of the different types of munitions made for the different Governments, it is comprehensive and convenient.

As a general guide to one who is contemplating the manufacture of munitions with standard shop equipment, it would be of considerable value.

As a handbook for the student, it would prove not only convenient but valuable in giving him an idea of the general and detail requirements of munitions manufacture.

The authors deserve great credit for the thoroughness with which the subject has been covered. We all realize, however, that the progress which has been made in the manufacture of munitions since the book was published and the tendency to specialize in munitions manufacture, owing to the large quantities which the United States Government is now having made, would necessitate the use of the information in this book with care and caution.

Frederick A. Waldron.

Shop Expense Analysis and Control

Shop Expense Analysis and Control. By Nicholas Thiel Ficker, Consulting Industrial Engineer and Lecturer at N. Y. U. School of Commerce. The Engineering Magazine Company, New York, 1917. Cloth, 6 x 9 in., 236 pp., 20 illustrations. $3.

This book is not a general treatise on cost finding, but treats almost entirely of the problems that center around manufacturing expense and its allocation. The book consists of twelve chapters, the first eight of which were published originally in *The Engineering Magazine*. The titles and content of these chapters are as follows:

1 Establishment of the Unit of Time as a Basis of Distribution
2 Machine Expense and Material Expense
3 Classification and Interpretation of General Ledger Accounts Pertaining to Production
4 Distributing Manufacturing Expense to Production Centers and Segregating Power Expense
5 The Standardization of Rent Expense Distribution
6 Depreciation, Insurance, Taxes and Interest
7 The Machine Unit System
8 Current Variation Ratio for Adjusting Current Costs
9 Organization
10 Waste in Manufacturing
11 Graphic Determination of Costs
12 Standard Reports.

The object of the author, apparently, is to call special attention to the difficult problems involved in distributing expense burden in manufacturing plants. The treatment of the problem, however, is not very general, but describes the methods which the author believes are best for this purpose. These methods might or might not be applicable to every plant, depending on the industry and the size of the plant. The author's discussion of the problems of distributing expense burden, however, is clear and illuminating, and is based obviously on actual experience.

No theories are advocated that are especially new, but many of the author's methods and forms are both interesting and instructive, though all will not agree with some of his conclusions. The book is not as well balanced as one would wish. Too much space is devoted to Chapter 10, for instance, to detailed descriptions of wasteful methods, and the review of the principles of organization given in Chapter 9 covers ground that all who will read the book are thoroughly familiar with. On the other hand, little or nothing is said of methods other than those advocated by the author, which, as has been stated, may or may not be applicable to a given factory.

The book, however, will be interesting and helpful to managers, cost accountants and students of such matters, and should be in every library that is devoted to this line of work.

Dexter S. Kimball.

Laws of Physical Science. By Edwin F. Northrup. J. B. Lippincott Co., Philadelphia, 1917. Leather, 5 x 8 in., 210 pp. $2.

This book contains a collection of general propositions or laws of science grouped under the six headings Mechanics, Hydrostatics, Hydrodynamics and Capillarity, Sound, Heat and Physical Chemistry, Electricity and Magnetism, and Light, together with a combined author and subject index, arranged alphabetically.

The leading idea of the book is a most praiseworthy one, and the volume undoubtedly fills a gap in the reference literature of science. There are many publications giving more or less complete collections of tables of constants, formulæ, etc., and hitherto these have to some extent made up for the absence of a dictionary of physical laws, but the advantages of a book dealing entirely and systematically with these laws, which thus provides the authorities a historical and logical foundations for these tables, are obvious.

The typographical arrangement of the book is somewhat poor, and the use of italics in formulæ and for reference letters would be a decided improvement. For example, on page 37, to point out only one place, the roman letter "*l*" and the numeral "1" are indistinguishable.

Much remains to be done, however, before the book can really be considered "a very epitome of the world's heritage of the fundamentals of its knowledge and wisdom," as stated in the preface. Thus, looking over the index, we find no mention of the names of Arrhenius, Bunsen, Becquerel, Lavoisier, Quincke, Lehmann, Roentgen, Sir Oliver Lodge, and others; nor are there any references to Hertzian waves, X-rays, N-rays, cathode rays and dissociation. The development and present

status of the periodic law deserves more comprehensive treatment than the perfunctory reference to Mendelieff on page 97. However, a good beginning has been made in a most useful undertaking and it is to be hoped that in the second edition the author will have due regard to possible improvements, some of which have been referred to here.

Paint Researches and Their Practical Application. By Henry A. Gardner Washington, D. C. (privately printed), 1917. Cloth, 6 x 9 in., 384 p., 155 figs. $5.

In this volume the author summarizes the investigations which he conducted at the Institute of Industrial Research for the Educational Bureau of the Paint Manufacturers' Association of the United States. Chapters are included on the following subjects: The Growth of the Prepared Paint Industry and Its Relation to the Work of the Painter; The White Pigment Industry; Physical Characteristics of Pigments and Paints; Tests of Lithopone; Washington Paint Oil Tests; Paint Protection for Portland-Cement Surfaces; Paints to Prevent Electrolysis in Concrete Structures; Paints for Metal; Marine Paints; Arlington Paint Tests; Observations on Painted Lumber; Impregnated Panel Tests; Fire Retardent Paints for Shingles and Other Wooden Structures; The Composition of Paint Vapors; The Toxic and Antiseptic Properties of Paints; The Light-Reflecting Values of White and Colored Paints; Formation and Inhibition of Mildew in Paints; Fungi on Painted Surfaces; Changes Occurring in Oils and Paste Paints, Due to Autohydrolysis of the Glycerides; The Effect of Pigments Upon the Constants of Linseed Oil; Storage Changes in Vegetable and Animal Oils; Paint Driers and Their Application; Miscellaneous Oil Investigations; The Application of Paints and Finishes to Wood.

American Hydroelectric Practice: A Compilation of Useful Data and Information on the Design, Construction and Operation of Hydroelectric Systems from the Penstocks to Distribution Lines. By William T. Taylor and Daniel H. Braymer. McGraw-Hill Book Co., Inc., New York, 1917. Cloth, 6 x 9 in., 439 pp., 258 figs. $5.

This is not a textbook on the fundamentals underlying the design and construction of the parts of a hydroelectric system, but a compilation of the practical and essential features of design, construction and operation as used in many plants, interpreted and arranged for use by designers and engineers. Contents: General Survey of Water-Power Engineering; Low, Medium and High Head Developments; Layout and Selection of Plant Equipment; Transmission Line Construction and Operation; Plant Line and Substation Costs; System Operation and Economics; Special Plant and Line Problems; Data, Reference Tables and System Diagrams.

War-ships. By Edward L. Attwood, M. Inst. N. A., Member of the Royal Corps of Naval Constructors, etc. Longmans, Green & Co., London and New York, 1917. Sixth edition. Cloth, 6 x 9 in., 338 pp., 209 illustrations. $4 net.

This textbook on the construction, protection, stability, turning, etc., of war vessels, while prepared primarily for the use of naval officers taking the course in naval architecture at the Royal Naval College, Greenwich, and amplified in certain particulars to meet their special requirements, is, nevertheless, believed by the author to be well adapted to serve as an introduction to the subject for students generally. The present edition, it is stated, has been modified in many places to take account of the rapid change of practice in recent years.

Handbook of Chemistry and Physics: A Ready-Reference Pocket-Book of Chemical and Physical Data. Fifth Edition. The Chemical Rubber Co., Cleveland, O., 1917. Cloth, 4 x 6¾ in., 414 pp. $2.

In the present edition of this compact, easily portable and fairly comprehensive reference work, the text, it is stated, has been carefully revised and brought down to date and a large number of new tables have been added.

Export Trade Directory 1917-1918. Compiled by B. Olney Hough. Johnston Export Publishing Co., New York, 1917. Cloth, 6 x 9 in., 537 pp., 1 map. $5.

Contents: Export Merchants in the United States; Manufacturers' Export Agents, Managers of Export Departments and Export Brokers; Leading Bankers Engaged in Foreign Exchange Business; Foreign Exchange Brokers; Marine Insurance Companies in New York City; Foreign Freight Forwarders; Some Export Trucking Companies in New York City; Steamship Services to Foreign Ports; How to Ship to Foreign Markets; Consuls of Foreign Countries in the United States; United States Consular and Commercial Representatives in Foreign Countries; Associations for the Promotion of Export Trade.

Workmen's Compensation Law: Personal Injury by Accident Arising Out of and in the Course of the Employment. By P. Tecumseh Sherman. N. Y., Workmen's Compensation Publicity Bureau, New York, 1916. Paper, 6 x 9 in., 67 pp. $2.

This is a compilation of the decisions construing the British law on the subject, with abbreviated summaries of the relevant portions of the French and German laws. These precedents will be useful, the author believes, in defining the meaning of "accidents due to risk of work" as used in the American statutes.

Gas Chemists' Handbook. Compiled by Technical Committee, Sub-Committee on Chemical Tests, 1916, of the American Gas Institute, C. C. Tutweiler, Chairman, A. F. Kunberger, Editor, New York, American Gas Institute. Cloth, 6 x 9 in., 354 pp., 67 illustrations. $3.50.

The present handbook, a revision of the one compiled in 1914, presents methods for sampling and testing the material used in gas manufacture. Contents: Raw Materials; Products of Gas Manufacture; Impurities in Gas; Tar Products; Miscellaneous and Tables.

United States Artillery Ammunition: 3 to 6 in. Shrapnel Shells, 3 to 6 in. High Explosive Shells and Their Cartridge Cases. By Ethan Viall. McGraw-Hill Book Co., Inc., New York, 1917. Cloth, 9 x 12 in., 98 pp., 171 figs. $2.

This work is intended to give shop men, engineers and manufacturers an accurate knowledge of the sizes, tools, shop work and gages for the more commonly used United States shells and cartridge cases. The descriptions are in minute detail and accompanied by numerous dimensioned drawings.

Office Organization and Management. By Carl C. Parsons. La Salle Extension University, Chicago, 1917. Leather, 6 x 8 in., 313 pp., 59 figs. $2.50.

A work treating of organization, management, layout, equipment, methods, systems, records, forms, employees, etc., and based on observation of the methods used in the offices of various large companies.

Industrial Preparedness. By C. E. Knoeppel. The Engineering Magazine Co., New York, 1916. Cloth, 5 x 7½ in., 145 pp. $1.

A study of Germany's military and industrial preparedness intended, the author states, to point the way to national greatness through the right kind of social, industrial and military preparedness.